Sveriges lantbruksuniversitet
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Faculty of Landscape Architecture, Horticulture and Crop Production Science

Evaluation of local knowledge applied by farmers towards management of crop pests and diseases in the Masaka region, Uganda

Utvärdering av bönders lokala kunskap om skadegörare och deras bekämpning i Masaka Regionen, Uganda

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Foreword

“Systemic thinking is the discipline which makes visible that our actions are interrelated to other people’s actions in patterns of behaviour and are not merely isolated events.” (Flood, 1999, p. 19)

This thesis faces the challenge of treating a largely natural science related topic with the tools and perspective of social science. As described by Lieblein *et al.* (2007), the aim of the Agroecology MSc programme is “an understanding of multifunctionality, complexity, and uncertainty of performance of agroecosystems” (p.37), and I have tried my best to apply this understanding to the topic. I consider this an appropriate approach in congruence with the above quote as well as the demands of an agroecologist, especially in a continent like Africa where farming systems are characterised by a high heterogeneity (Giller *et al.*, 2010). Pest and disease management is a part of a complex system any farmer is confronted with, and even though the actual methods of management follow the rules of natural science, the ability of farmers to apply them depends on a much wider range of socio-economical factors.

Having been to Uganda in an agricultural context before I studied Agroecology, I was now able to compare and become aware of the skills which I have gained through the two-year Agroecology programme. The most important things which I feel I have learnt are systemic thinking, the application of participatory rural appraisal tools and the ability to gather information through exchange with people from different backgrounds. The awareness that there are no ‘silver bullets’ and that ‘black and white thinking’ cannot lead to workable solutions, nor to a fruitful dialogue between all the stakeholders involved, is another understanding which I ascribe to my studies. Finally, the fusion of natural science with social science has proven to give highly valuable insights to me, as well as the ability to assess agricultural systems in a way which I always felt is necessary, that is by considering all their various and diverse aspects and the parties involved.

If we want to tackle the problems of contemporary agriculture and food systems, we require “methods which will be eclectic, inventive, adaptable, and open to unexpected information (...) and involving rural people themselves as partners in research.” (Chambers, 1983, p. 47). I hope that my research and this dissertation do justice to both the farmers’ situation and the demands from an agroecologist, and that they may inspire and help future projects and research to improve the livelihoods of Ugandan farmers.

Summary

Agriculture is the most important economic sector of Uganda and it employs roughly 80 % of the work force. Ninety per cent of the country's farmers are smallholders. The Masaka district is the country's agricultural hub for coffee (*Coffea* spp. L.) and the most important food crops are banana (*Musa* spp. L.), beans (*Phaseolus vulgaris* L.), cassava (*Manihot esculenta* Crantz.), maize (*Zea mays* L.), sweet potatoes (*Ipomoea batatas* (L.) Lam.) and other tropical fruits, vegetables and cereals. Pests and diseases have been presenting increasing problems due to the climate change and newly introduced pathogens and pest species. At the same time, the population growth has led to an increased land pressure and chemical input use, which has impacted the soil fertility, the environment and the health of farmers and consumers. Indigenous knowledge, such as the use of pesticidal plants, is at the risk of becoming extinct due to a lack of documentation and scientific evaluation.

This thesis is an attempt to collect and scientifically document the knowledge of local farmers on traditional methods of pest and disease management in the Masaka region through qualitative research. It furthermore tries to investigate reasons for a lack of knowledge transfer to farmers from previous generations as well as from agricultural advisors from the governmental side and from non-governmental organisations (NGOs), and to explore possibilities of improvement of knowledge access for farmers. The research questions were developed focussing on the pests and diseases farmers are facing in the region, their methods of management, the effectiveness of these methods, their sources of knowledge behind them, opinions of farmers and advisors on chemical pesticides, and possibilities to improve farmers' knowledge on pest and disease management.

To address these questions, semi-structured interviews were conducted in the Masaka region on seven different days with 43 farmers in seven different locations. Farmers were asked to discuss questions in focus groups in four locations. Additionally, interviews were conducted with advisory staff from the government and with employees from non-governmental organizations (NGOs). Over the whole period, literature was collected and reviewed.

It was found that most local methods of pest management have been taught to farmers by agricultural advisors rather than being adopted from the parents, mostly because the previous generations were not facing the same problems as the present one. At the same time, the knowledge transfer to farmers from extensionists and NGOs was limited due to a lack of financial support from the government, and there was also a distinct lack of exchange between scientists and farmers. As a consequence, there was both a paucity of knowledge about alternatives to pesticides and the appropriate use of chemical methods. Another issue found was that newly introduced cattle races require high chemical input.

The problems found can only be solved by a combination of different measures. The extension system needs to receive more financial support, to revise its policy framework, and to focus more strongly on the farmers' education in traditional methods. NGOs, which are already teaching such methods, need to reach more farmers and to develop a better overarching managerial system and collaboration both amongst each other and with the governmental advisory network. Lastly, academics and universities need to improve their exchange with the practitioners, as from the side of the latter, openness to such an exchange exists to a large extent.

List of acronyms

ACMD	African Cassava Mosaic Disease
ACMV	African Cassava Mosaic Virus
CADeP	Congregational Agricultural Development Programme (Kulika Uganda)
CWD	Coffee Wilt Disease
DAP	Diammonium Phosphate
DATIC	District Agricultural Training Information Centre
DDT	Dichlorodiphenyltrichloroethane
EADD	East African Dairy Development Project (Heifer)
EPOPA	Export Promotion of Organic Products from Africa
FFL	Farmer-First-and-Last
GDP	Gross Domestic Product
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development
ICRAF	World Agroforestry Centre
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
JIDDECO	Jinja Diocesan Development Coordinating Organization
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries (Uganda)
MADDO	Masaka Diocesan Development Organisation
NAADS	Uganda National Agriculture Advisory Services
NARO	National Agricultural Research Organisation
NGO	Non-Governmental Organization
NOGAMU	National Organic Agricultural Movement of Uganda
NUCAFE	National Union of Coffee Agribusinesses and Farm Enterprises
PRA	Participatory Rural Appraisal
SCC-Vi	Swedish Cooperative Centre-Vi Agroforestry
SEK	Swedish Krona
TEK	Traditional Ecological Knowledge
TOCIDA	Tororo Community Initiated Development Association
TOT	Transfer-of-Technology
UGX	Ugandan Shilling
UNFFE	Uganda National Farmers Federation

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1. Purpose of this research

Originally being a common means of pest and disease management in pre-industrial times, the use of pesticidal plants has nowadays been assigned a new role as a more sustainable and environmentally friendly alternative to synthetic agrochemicals (Mwine *et al.*, 2010). Uganda stands out as the country within Africa with the most organic land (Willer & Kilcher, 2012), and Masaka is the region within Uganda with most farmers converting to organic agriculture. Organic farming prohibits the use of synthetic agrochemicals and promotes the use of sustainable techniques such as the use of plant-based pest remedies (Mwine *et al.*, 2010). However, in many developing countries including Uganda, there is a lack of documentation and scientific evaluation of traditional methods such as medicinal plants and botanicals for pest management (*ibid*). The original purpose of this research was thus to collect and scientifically document the knowledge by local farmers on the use of pesticidal plants as well as other traditional methods of pest management. During the course of the research, further questions came up and shall be more deeply investigated, including reasons for a lack of knowledge access for farmers and knowledge exchange between farmers. Lastly, possibilities to improve farmers' knowledge shall be explored.

2. Background and Literature review

2.1 Study area

Uganda is a landlocked country straddling the equator in Eastern Africa (LoC, 2010). The equatorial climate is moderated by relatively high altitudes in most areas of the country, thus mean annual temperatures range from about 16° C to 25° C (*ibid*). The two rainy seasons start in April and October, with the lowest rainfall occurring in the northeast (*ibid*). The country has a population of over 35 million people with ten main ethnic groups (Harms *et al*., 2013). Its land expanse covers a surface area of 93,064 sq miles, with 82 % of it suitable for agriculture (Heifer, 2013 b). The country can be divided into five agroecological zones – including sub-humid and humid, arid and semi-arid in northeast region and part of southern; and highlands in the east and southwestern regions (*ibid*). Eighty-eight per cent of the population live in rural areas (*ibid*). Only 37,7 % of the population have access to clean water and the ranking in the Human Development Index was 157 of 182 in 2009 (Vi Agroforestry, 2013 b). The country has generally fertile soils and regular rainfall and thus huge agricultural potential, particularly in the South (Harms *et al.*, 2013; Send a Cow, 2013b). Yet environmental degradation, lack of skills, and shortage of quality livestock hampers farmers' attempts to escape poverty and makes many of them subsistence farmers (Send a Cow, 2013b). Still, agriculture is the most important economic sector, employing some 80 % of the work force and representing some 24 % of the GDP (Harms *et al.*, 2013). In addition to coffee, Uganda exports fish and fish products, tea (*Camellia sinensis* (L.) Kuntze), cotton (*Gossypium spp.* L.), flowers and horticultural products (*ibid*). Ninety per cent of Uganda's six million farmers are smallholder farmers who are characterised by a low resource base in terms of land (less than 3 ha per household), capital and labour (dependence on family labour), and by limited farm management skills (*ibid*).

The Masaka district is located between 31° 12´ and 32° 06´E and 0° 48´ and 1° 20´S in South Uganda along the shores of Lake Victoria (Figure 1) (Mwine *et al.*, 2010). It has a bimodal type of rainfall with an annual average of 1200 mm and mild equatorial temperatures ranging between 22 and 26°C (*ibid*). There are two growing seasons from March to June and October to December which supports the growing of crops the whole year around (*ibid*). The principal cash crop in this region is coffee (*Coffea* spp), while the most important food crops are banana (*Musa* spp. L.) and beans (*Phaseolus vulgaris* L.), followed by cassava (*Manihot esculenta* Crantz.), maize (*Zea mays* L.), sweet potatoes (*Ipomoea batatas* (L.) Lam.) and other tropical fruits, vegetables and cereals (Fungo *et al.*, 2011). Coffee has its main harvest in May until July and can have a smaller harvest in November-December. Robusta coffee (*Coffea canephora var. robusta* L. Linden) contributes to over 80 % of the total production while the remaining part is Arabica coffee (Egonyu *et al.*, 2009). Bananas have recurring flowers and are thus grown throughout the year; however their harvest decreases from August till December. Beans are generally planted after the more important crops both in the first and second growing season and have a growth period of two to four months according to the variety (*ibid*). Cassava and sweet potatoes are grown throughout the year (*ibid*). Of the two, cassava is the most important root crop in Uganda (*ibid*). Maize is the most important cereal crop and is grown in both seasons (Kalule *et al*., 2006). Onions (*Allium cepa* L.) are also harvested twice, whereas Irish potatoes (*Solanum tuberosum* L.) are only grown in the wet season. Due to its favourable climatic conditions, the region is the country's agricultural hub of coffee and it is furthermore characterized by a growing number of agriculture-related organisations striving for positive changes (Mwine *et al.*, 2010; FSD, 2013).

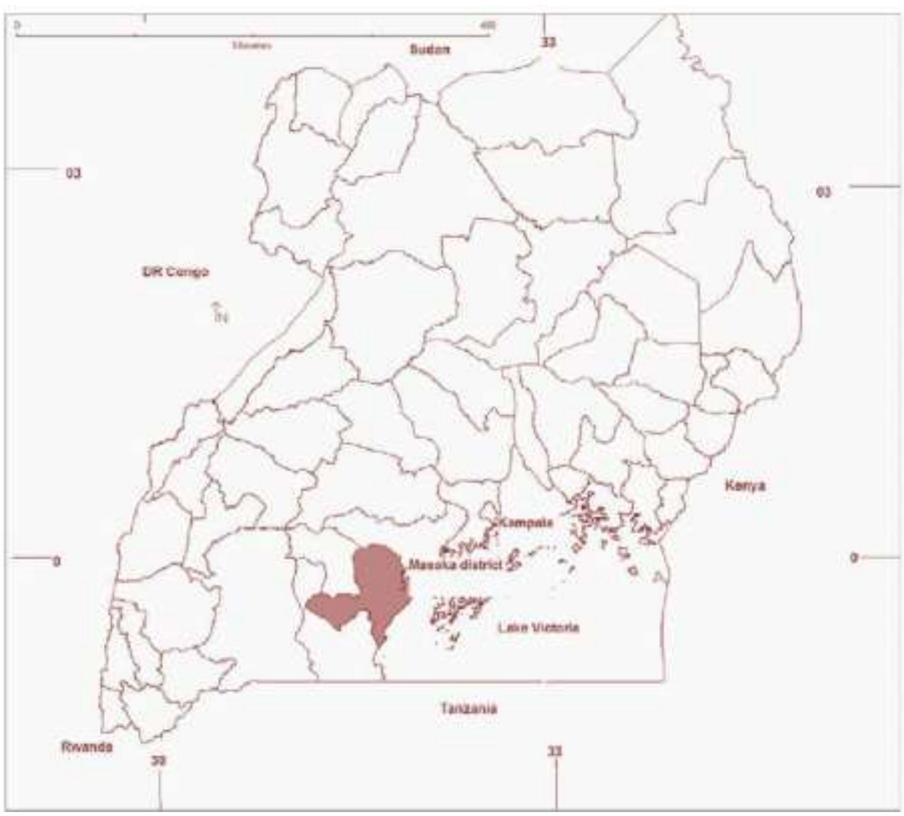

Figure 1: Location of the Masaka district in Uganda (from J. Mwine, 2010)

2.2 Problems in the agricultural sector of East-Africa and Uganda

East-Africa is poorly endowed with minerals, oil or coal and thus its main industries are based on agricultural raw material (Ngugi *et al.*, 1978). European settlers introduced new crops such as maize, wheat (*Triticum spp.* L.), tea and coffee (*ibid*). At the same time, African agriculture was neglected in favour of the colonial farmers, so that most African farmers were subsistence farmers in the first half of the 19th century (*ibid*). Only from the second half of the 19th century, African farmers have been supported and have thus experienced improvements (*ibid*). However, the increase in population densities had led to an increased land pressure with a consequent rise in external inputs (Giller *et al.*, 2010). This had a negative impact on the soil fertility (*ibid*). At the same time, traditional crops have been increasingly substituted by staple foods such as maize or cassava (Figure 2) (*ibid*). Factors such as the low level of education which results in conservative and often ineffective agricultural practices, the lack of modernisation e.g. in terms of farming tools, and the inefficient transport system which increases the risk of spoilage of produce, are additional challenges (Ngugi *et al.*, 1978). Furthermore, farmers are often exploited through middlemen and they suffer from lack of capital and inability to take loans for investments (*ibid*). Fluctuations of commodity prices cause instable farmers' profits, and a general poor attitude towards agriculture as an occupation has caused many of them to migrate into cities and leave agriculture to those who are less educated (*ibid*). Pests and diseases have continuously been presenting a problem, especially in combination with the problem of droughts and unreliable rainfall patterns (*ibid*). Poor storage practices have been increasing the problem of spoilage through pest damage, leading to an estimated loss of production of approximately 20 % (*ibid*). Lastly, land tenure presents a major problem in East African countries as most land is owned by tribes or clans and thus individual farmers are left with little incentive to look after land properly or to invest in long-term programmes (*ibid*).

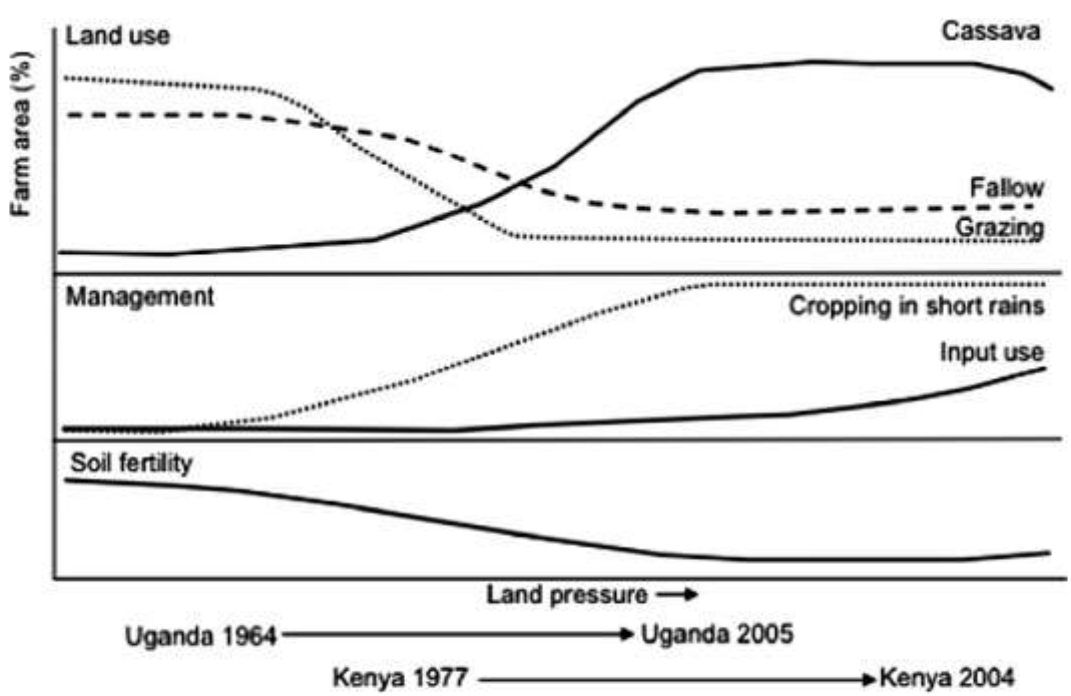

Figure 2: Changes in cropping patterns in eastern Uganda and western Kenya over the past 40 years showing the increase in the land area cropped with cassava (Giller *et al*., 2010, modified from Fermont *et al*., 2008).

2.3 Management of pests and diseases

Worldwide, the loss potential of pests has been estimated at 26–30 % for sugar beet (*Beta vulgaris* L.), barley (*Hordeum vulgare* L.), soybean (*Glycine max* L.), wheat and cotton, and 35-40 % for maize, potatoes and rice (*Oryza sativa* L.) (Oerke & Dehne, 2004). African agriculture is characterized by small-scale farming, and its diverse traditional systems provide natural shelter for enemies of pests, thus keeping them at low levels (Abate *et al.*, 2000). However, the agricultural intensification due to an increased demand for food production, along with the introduction of foreign pests, are major constraints for agricultural productivity (*ibid*). Uganda is one of the largest producers of bananas in the world with about 9 million tonnes annually, but a decline in banana production has been noted over many years both due to pests and diseases and to political, social and sanitary problems (DFID, 2004). The longevity of plantations has furthermore declined from 30 years or longer to less than ten years (*ibid*). Reasons for yield declines have been found to be related to soil fertility, to the pest complex of weevils, nematodes, fusarium wilt and viruses as well as to the poor genetic diversity of banana clones (*ibid*).

Diseases can be caused by bacteria, fungi and viruses while pests belong to the phylum *Arthropoda* or *Nematoda*. According to Ngugi *et al.* (1978), the same principles underlie the control of all plant pests. The prerequisites for successful control are to understand of the nature and consequences of the damage which can be caused, to understand the biology of the pest and be able to estimate its population, to be aware of the effect of the weather and seasons on the pest and to find out whether the pest has natural enemies. Wyss *at al.* (2005) have proposed a model for arthropod management in organic crops, which is divided into four phases, the first of which comprises cultural methods. The second, third and fourth phase involve vegetation management, biological control and use of insecticides of biological or mineral origin (Zehnder *et al*., 2007).

Cultural methods and vegetation management include crop location, early planting, manuring, use of clean planting materials, field hygiene, close season and crop rotation, trap cropping, weed control, tillage practises, growing resistant varieties and quarantine (Ngugi *et al.*, 1978; Zehnder *et al*., 2007). The selection of specific practises must be based on an overall risk assessment (Zehnder *et al*., 2007). In some cases a primary pest can be avoided by choosing a site which is ideal for the crop and natural enemies but unfavourable for the pest (*ibid*). Early planting gives crops an early start and thus enables them to grow more vigorously and resist pests better (Ngugi *et al.*, 1978; Zehnder *et al*., 2007). This can also be achieved by the application of organic manures, as plant resistance is linked to optimal physical, chemical and biological properties of the soil (*ibid*). The use of clean planting materials (for example by buying them from reputable sources), and field hygiene by the destruction of infected crops and burning affected branches, are additional preventive measures (Ngugi *et al.*, 1978). In a 'close season' or 'dead season', nobody is allowed to grow a particular crop in a specific season so as to break the life cycle of the pest (*ibid*). For this method to be effective, it is crucial that everybody uses it in a given area, and that alternate hosts for the pests are destroyed (*ibid*). Crop rotation achieves the same result and can be applied in systems of annual crops (*ibid*). It is most effective against pests which do not disperse over great distances or which overwinter in or near host crop fields (Zehnder *et al*., 2007). Trap cropping is based on the presumption that the trap crop is more attractive to the pest as a food source or oviposition site than the main crop (*ibid*). Especially the use of combined push-pull trap cropping has proven successful for example in east African corn production (*ibid*). Weed control eliminates weeds which can harbour pests and diseases or act as alternate hosts. Soil cultivation furthermore kills or exposes pests to their enemies and prevents further multiplication of the pests (Ngugi *et al.*, 1978). In organic farming, conservation tillage is used primarily for soil and water conservation, but it can also significantly affect pest and natural enemy abundance (Zehnder *et al*., 2007). Resistant varieties have been developed for wheat, sorghum (*Sorghum bicolor* (L.) Moench), cotton, groundnut (*Arachis hypogaea* L.), Irish potato and maize. However, the production of resistant varieties requires very long-term breeding programmes and is furthermore prone to the risk of breakdown of resistance (Ngugi *et al.*, 1978). It has limited application for pest control in conventional agriculture due to economic reasons (Zehnder *et al*., 2007). Quarantine, finally, serves to prevent the introduction of new pests and diseases into the country or the spread of pests to other areas within the country (Ngugi *et al.*, 1978). If infestation has already occurred, hand collection of pests, trapping and heat treatments can be applied (*ibid*).

Biological control is a term used to describe any action which increases or supplements the factors naturally controlling a pest or a disease. It includes the introduction of natural enemies such as predators and parasitoids, fungi, bacteria, viruses or nematodes (Pury, 1968). Inundation biocontrol involves the use of living organisms to control pests when control is achieved exclusively by the released organisms themselves, while inoculation biocontrol indicates the intentional release of a biological control agent with the expectation that it will multiply and control the pest for an extended period, but not permanently (Zehnder *et al*., 2007). Classical biocontrol is the intentional introduction of an exotic, usually coevolved, biological control agent for permanent establishment and long-term pest control (*ibid*). Beetle banks or flowering insectary strips can enhance the efficacy and local abundance of natural enemies (*ibid*). Although biological control is not widely used in East Africa (Ngugi *et al.*, 1978), successes are reported when *Rodolia* ladybirds (*Rodolia cardinalis* (Mulsant) for the control of the cottony cushion scale, with the parasitic wasp *Anagyrus nr. Kivuensis* Compere against the coffee mealy bug (*Planococcus kenyae* (Le Pelley)), and in the case of weaver ants (*Oecophylla* spp. Smith) against the coconut bug (Pury, 1968).

The application of insecticides of biological or mineral origin, pheromones for mating disruption, and repellent agents as physical barriers, are additional strategies used as a necessity for the control of pests in organic agriculture (Zehnder *et al*., 2007). Botanical insecticides include pyrethrum, rotenone, neem (*Azadirachta indica* A. Juss) and other plant oils. Beside those on the market, organic farmers may also grow plants such as garlic (*Allium sativum* L.) and black pepper (*Piper nigrum* L.) and extract them to yield teas and washes to control insects such as aphids (*ibid*). A study by Mwine *et al*. (2010) found that currently 34 species belonging to 18 families are being used for the production of pesticidal extracts in the Masaka district, which is described as the only affordable alternative to agrochemicals for most small farmers in this region.

Chemical control involves the dusting, spraying or fumigation of a crop with a substance which is harmful to a particular organism. The risk they pose comes from the fact that they may affect other than the target organism and that they may remain indefinitely in the soil, water or food crop. The possible modes of destruction of pests are by ingestion (stomach poisons), by contact and by suffocation (fumigants). Destruction by contact is the mode of the most commonly used pesticides, for example Malathion and most fungicides. They are far less selective than stomach poisons, such as systemic pesticides, which can be used against aphids and mealy bugs. Fumigants are used against nematodes or to sterilize the soil against soil-borne diseases.

“Integrated control” or “integrated pest management” (IPM) aims to combine chemical and cultural control methods (Ngugi *et al.*, 1978). It recognises the fact that any measure of pest control can set in motion complex chain reactions of the ecosystem and tries to minimise harmful side effects to the ecological balance (*ibid*).

Major pests to be dealt with in the Masaka region in declining order of importance include the banana weevil, the bean fly, cereal stem borers, pod feeders, the grain moth, rodents, moths, termites, birds, aphids and cutworms (Mugisha-Kamatenesi *et al.*, 2008). The pests and diseases most frequently named by the farmers and their management methods suggested in the literature are described in the following sections.

2.3.1 Coffee wilt

The coffee wilt disease (CWD) spread across Africa in the 20th century and caused hundreds of millions of dollars in lost earnings to farmers (Flood, 2009). In Uganda, the decline of coffee production and export which has been taking place over the last decade was mainly attributed to the effect of coffee wilt disease which was first reported in western Uganda in 1993 (Egonyu *et al.*, 2009). Unlike many other diseases of coffee, CWD can kill a mature tree within six months after the appearance of the first external symptoms (Rutherford, 2006).

Coffee wilt is caused by the fungus *Fusarium xylarioides* (Steyaert) Delassus (sexual form *Gibberella xylarioides* R. Heim & Saccas) which is soil-inhabiting and penetrates through wounds into the roots (IB, 2012a; Flood, 2009). The spores are spread by wind, rain, insects and through management of the plantation (IB, 2012a). The incubation period from first symptoms to death is usually 2-3 months (*ibid*). The initial symptoms are chlorosis, wilting and drying of the leaves as well as vertical and spiral cracks of the bark, blue-black streaks in the wood and the occurrence of fungal fruiting bodies producing spores in the bark (Rutherford, 2006; IB, 2012a). The disease can lead to a gradual and often unilateral dieback and defoliation which ultimately leads to the death of the tree (Rutherford, 2006). Infected berries turn red and seem to ripen prematurely (Rutherford, 2006). Seed infection causes blue-black discolouration of the parchment and silver skin (IB, 2012a).

Figure 3: Coffee tree which has almost died from coffee wilt (picture: Johanna Unger)

According to the literature, the effect of chemical pesticides is limited through to the vascular nature of the pathogen (Rutherford, 2006). Recommended phytosanitary practises include the disinfection of tools, using clean planting material and the uprooting and burning of affected trees (*ibid*). In regions where the disease is appearing for the first time and when disease levels are still low, roguing of infected trees at the earliest opportunity can minimise the disease spread, especially when trees up to 10 m away from the diseased tree are rogued (Musoli *et al.*, 2008). Current research on the management of coffee wilt is being conducted in the direction of host resistance, which is considered to provide a long-term and stable solution to the problem (Rutherford, 2006).

2.3.2 Bacterial Banana wilt

Bacterial banana wilt (BBW) is a bacterial disease caused by *Xanthomonas campestris pv. Musacearum* (Yirgou and Bradbury) (UCE, 2013). Having been identified in Ethiopia in the 1960s where it affected wild enset (*Ensete ventricosum* (Welw.) Cheesman), it was first reported in Uganda in 2001, where it has affected several cultivated varieties of banana and has led to yield losses of 90 % on some farms (UCE, 2013; CABI, 2009). The pathogen is easily transmitted by insects, which has been the cause to its rapid rate of spread, and so far no resistance has been observed (CABI, 2009). First symptoms are yellowing and distortions in young plants and wilting of young leaves (*ibid*). Older leaves develop yellowing, necrosis and breakage of the leaf basis and vascular bundles show a yellow or pinkish discolouration and may ooze a cream to pale yellow ooze when cut (*ibid*). Other than in other bacterial wilts of banana, the ooze may also fill the air spaces within the leaf bases (*ibid*). Flowers and developing fruit bunches may blacken and shrivel and exhibit discolouration from pale yellow to reddish-brown (*ibid*). Later, pseudostems reveal yellowish colouration and fruits ripen unevenly and prematurely and have dark brown placental scars and flesh with yellowish blotches (UCE, 2013).

Figure 4: Banana Wilt (picture: Johanna Unger)

According to the literature, conventional chemical control measures have not proven cost-effective and there is no information concerning host-plant resistance (CABI, 2009). Correspondingly, importance has to be given to cultural and preventive methods (*ibid*).

As bacterial banana wilt is transmitted by insects, control of insect vectors may provide a means of reducing disease spread (ibid). However, corresponding methods have not been identified yet (*ibid*).

Phytosanitary methods include the restriction of movement of all parts of banana and the local consumption of fruits from affected areas (*ibid*). Infected bunches may appear externally normal and thus increased surveillance is recommended for threatened areas (*ibid*). Sterilization of knives before pruning and harvesting will reduce the risk of spreading the disease (*ibid*). However, it has been found difficult by farmers to carry disinfectant and water (Smith *et al.*, 2008).

Recommended cultural practises have been cognisant of those control practises for other pests of banana (Smith *et al.*, 2008). For example, practices to prevent inflorescence infection, such as removal of unopened male flowers, have proven to be effective for other bacterial wilts of banana and are likely to be efficient for the wilt caused by *Xanthomonas campestris* (CABI, 2009). Uprooting and burying affected plants in the original outbreak areas, has reduced, but not prevented the spread of the disease in Uganda (*ibid*). Furthermore, even though the identification and removal of infected plants is seen as a key control measure, this practice is often impractical for the majority of farmers, and the dynamics of the bacteria populations have not been studied sufficiently to recommend an evidence-based approach for the safe removal of infected plants (Smith *et al.*, 2008). In general, more research on integrated pest management methods is strongly required (CABI, 2009).

2.3.3 Banana weevil

The banana weevil (*Cosmopolites sordidus* Germar) belongs to the order *Coleoptera*, family *Curculionidae.* It occurs in all banana growing countries of the world (IB, 2011a), although its severity is considered to be greatest in Africa (DFID, 2004). It has been reported as relatively unimportant in commercial Cavendish plantations, but it has contributed to the disappearance of highland cooking banana in parts of East Africa (IB, 2011a). This weevil was recognised as a major pest in Uganda and Tanzania for a long time and was introduced to Kenya in the late 1950s (Pury, 1968). Eggs are laid singly in the base of the pseudostem and the larvae hatch after six to eight days under tropical conditions (IB, 2011a). The young larvae make irregular tunnels in the surface tissues of leaves and then the corm and rootstock (*ibid*). The tunnels promote fungal infections and the injuries can affect root initiation and sap flow in the plant (*ibid*). Infested plants show yellow green and floppy foliage, their shoots often wither and the plants are easily blown down by winds (*ibid*). The larvae pupate in 20 to 25 days and adults emerge from the pupae 5 to 7 days after pupation (*ibid*). They feed on dead banana plants, newly cut stems and other decaying plant material and can live up to two years (*ibid*). Females often lay their eggs in the end of a stem that has been cut down for harvesting, and thus stems should be cut below ground surface when bananas are harvested (Pury, 1968).

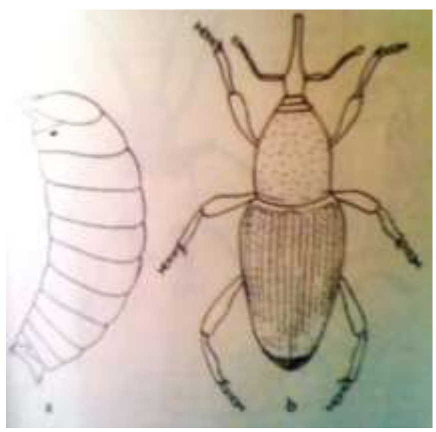

Figure 5: Banana weevil (*Cosmopolites sordidus*): a) larva b) adult (Pury, 1968)

The Swiss non-profit organization "Biovision Foundation for Ecological Development" strongly advises to substitute synthetic pesticides with methods with a longer-term effect, such as biopesticides, trapping, biological pest control, habitat management and cultural practices (IB, 2011a).

A recommended biopesticide is neem (*Azadirachta indica*), which is effective in fertile soils with moderate pest infestation and can be applied as seed powder or neem cake at planting or as a seed solution in which suckers are dipped, thus reducing egg laying as well as egg hatching rates (*ibid*).

In terms of trapping, there is the possibility of pseudostem traps and the more effective disk-on-stump traps which consist of corm slices placed on top of harvested plants cut at the rhizome (*ibid*). This attracts adult weevils to lay their eggs into these pieces which will dry out and kill the larvae through dessication (*ibid*).

Biological pest control can resort to predatory ants such as *Pheidole megacephala* Fabricius and *Tetramorium* spp Mayr, fungi such as *Beauveria bassiana* (Bals.-Criv.) Vuill. and *Metarhizium anisopliae* (Metchnikoff) Sorokin and some nematodes such as *Steinernema* and *Heterorhabditis* spp. Poinar (*ibid*). However, only predatory ants have been tested in Uganda so far and the application of biocontrol agents is generally still restricted by a lack of facilities and high costs (*ibid*).

Habitat management includes the planting of wild flower strips and hedgerows and the regulation of pests through conservation and enhancing of indigenous natural enemies (*ibid*).

Cultural practices are the methods with the most long-term effects (IB, 2011a). Clean planting material can be ensured by destroying or paring infested material to reduce the number of eggs and larvae and by treating suckers with hot water (52 to 55°C) for 15 to 27 minutes before planting (*ibid*). After harvesting, stems should be cut at ground level and the cut rhizome should be covered with a layer of soil to prevent the weevil's entry (*ibid*). Old stems can also be cut into small pieces and scattered for drying or used for trapping (*ibid*). To ensure vigorous plants, the application of mulch, removal of water suckers, cleaning mats of dead leaves, keeping the plantation free of weeds and proper fertisilisation are recommended practices (*ibid*). Previously infested land should never be replanted while old corms still remain on the ground or only little time has passed since remnants of the previous crop have been removed (*ibid*).

2.3.4 Coffee weevil (Black twig borer)

The black twig borer (*Xylosandrus compactus* (Eichhoff)) is native to Asia where it was a pest of Robusta coffee, but it has spread to other coffee growing regions in the world and affected Arabica coffee as well (FARMD, 2012). The first outbreak in Uganda was reported in 1993 and its most recent outbreak in 2008 infested 37,5 % of Robusta farms in two districts. The pest presented a new threat just after the country had recovered from the coffee wilt, which had at the same time overshadowed the first outbreaks of the borer and thus prevented control measures (Egonyu *et al.*, 2009). Females bore intro branches and suckers and the plant is destroyed through tunnelling as well as introduced pathogens, leading to the death especially of primary branches which bear the berries (FARMD, 2012; Egonyu *et al.*, 2009). First symptoms are necrotic lesions and wilting of leaves and twigs and the occurrence of entry holes surrounded by whitish dust (Egonyu *et al.*, 2009). Furthermore, the discolouration of infested branches is a typical symptom (*ibid*). The borer feeds on *Ambrosia* fungus and uses the host plant material as a medium for growing the fungus (*ibid*). The life cycle of the borer is completed in about one month, the males remain in the brood gallery while the females leave it to lay eggs in other branches or hosts (*ibid*). The black twig borer is one of the few species of ambrosia beetles that can kill live branches, which can cause the death of the entire tree (*ibid*).

Figure 6: Coffee tree affected by the Black Twig Borer (picture: Johanna Unger)

Though different insecticides have been used against the pest in India, the US and China, environmental and human health concerns, the difficulty to reach the concealed habitats of the borer and the question of cost for farmers create a need to devise an integrated pest management strategy (Egonyu *et al.*, 2009).

As humidity facilitates the ambrosia fungus upon which the borer feeds in its younger stages, infestations can be controlled by shade reduction (FARMD, 2012). Practices which promote tree vigour and health can aid recovery of coffee plants from damage through the borer (Egonyu *et al.*, 2009). Furthermore, pruning, especially the removal of unwanted suckers, and burning of infested twigs have proven to be effective cultural control methods (Egonyu *et al.*, 2009, FARMD, 2012). However, continuous pruning also reduces the number of berry bearing branches (Egonyu *et al.*, 2009). Biocontrol agents have yet to be investigated in Africa, for example the fungus *Beauveria bassiana* and ethanol-baited traps have been found to have potential for the management of the borer (*ibid*).

Adult females can be dispersed over several kilometers, especially when aided by wind, and females can reproduce without mating, both factors which make the borer a high risk quarantine pest in non-infested areas (*ibid*).

Exploration of physical, molecular and biochemical interactions between the borer and coffee to find methods of breeding resistance as well as an investigation of the factors governing the population dynamics of the pest can be expected to help prevent its spread and damage (*ibid*).

2.3.5 Maize stalk-borer

Lepidopteran stemborers are among the economically most important pests of maize and sorghum in Africa (Matama-Kauma *et al.*, 2007). In Uganda, the predominant species are the indigenous *Busseola fusca* (Fuller) and the invasive *Chilo partellus* (Swinhoe) *(ibid).* The African Maize stalk-borer (*Busseola* *fusca*) belongs to the family *Noctuidae* and is a common pest in many sub-Saharan African countries (IB, 2001d). The damage is caused by the caterpillars which first feed on young leaves and then enter into the stems, where they feed and grow for two to three weeks (*ibid*). Their extensive tunnels disrupt the flow of nutrients to the grain and weaken the stem so that it breaks and falls over (*ibid*). Young plants typically show "window-panes" in the leaf whorls and in severe attacks the central leaves die and form a characteristic withered "dead-heart" (*ibid*). Later generation caterpillars may bore into the maize cobs as they have a migratory nature (IB, 2001d; Matama-Kauma *et al.*, 2007).

Female adults usually lay eggs in batches of 30 to 100 under leaf sheaths from which the caterpillars hatch in seven to ten days (IB, 2001d). The caterpillars are blackish on hatching and later violet to pinkish white in colour (*ibid*). They lack hairs but have rows of small black spots along the body (*ibid*). When grown to a length of about 40 mm, they cut a hole in the side of the stem before pupating within the tunnel inside the stem (*ibid*). In dry or cold weather they enter into a resting period (diapause) of six months or more (*ibid*). The adults emerge from the pupae after one to two weeks and have a wingspan of about 25 to 35 mm (*ibid*). Their forewings are light to dark brown and the hindwings white to greyish-brown, though there is seasonal and geographic variation (*ibid*). Adult moths are active and lay their eggs during the night (*ibid*). There are several generations per year so that the numbers increase at the end of the season (*ibid*).

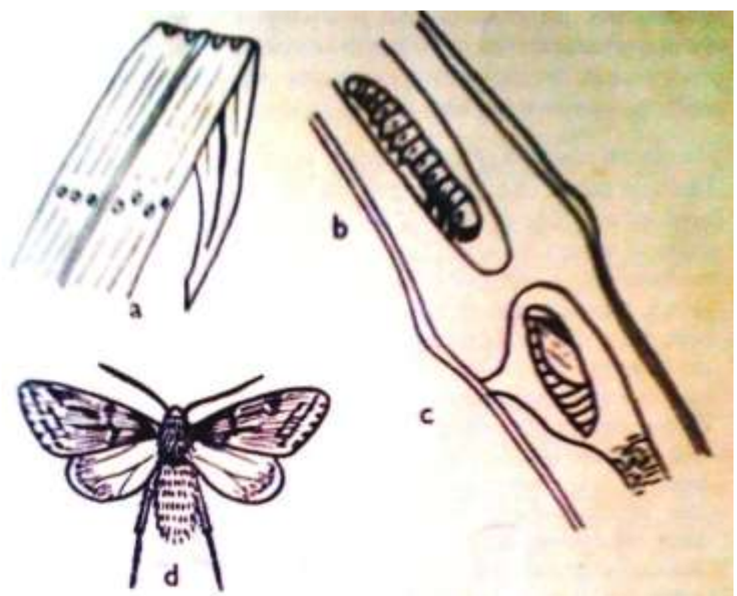

Figure 7: Maize stalk-borer a) windowing damage to leaf b) larva in maize stalk c) pupa in maize stalk d) adult (Pury, 1968)

Even though a well-timed application of chemicals has proven to be efficient in reducing stemborer numbers, the short time of exposure of the larvae before they enter the stem and the difficulties in timing the insecticide application sometimes make a regular application necessary, which implies high costs for small-scale farmers (Kalule *et al*., 2006). Cultural control methods include the management of crop residues, crop rotation and adjustments in sowing dates, however, they are difficult to be implemented on a large scale due to the dependency of sowing dates on rainfall as well as different farmers' practices and preferences (*ibid*). For example, farmers use residues as animal feed in the dry season, as a source for building and fencing materials and for the construction of shade (*ibid*).

An integrated pest management (IPM) approach, which would combine chemical and agronomic practices with cultural control methods, would likely be highly effective in controlling stemborer populations. Indigenous control methods include the application of ash in the plant whorl, uprooting affected crops, crop rotation, use of cow urine and the use of plants which repel stemborers, such as neem (*Azadirachta indica*), pineapples and sisal. However, these methods are used to a limited degree, possibly due to the loss of indigenous knowledge as well as the costs involved. Manual removal of stemborers is labour intensive and only kills visible insects. In a study by Kalule *et al*. (2006), pesticide application was found to be the most common control measure against stemborers, while indigenous and cultural control methods were only used to a limited degree and less than 50 % of farmers knew about the existence of alternative hosts for stemborers (*ibid*). Thus, further research programmes that disseminate alternatives to insecticides are recommended. Recently, the "push-pull" strategy which involves the combined use of intercropping and trap crop system has been demonstrated on fields in Uganda (*ibid*).

The severity of infestation and damage by the maize stalk-borer strongly depend on the cropping system and soil fertility, as the damage is aggravated by the poor nutritional status of the plant (IB, 2001d). Thus, practices such as cereal-legume rotations and the use of farmyard manure and green manure cover crops are important for management of the borer (*ibid*).

Lastly, the prevention of larval dispersal via increased mortality of eggs by egg parasitoids can contribute considerably to prevention of yield loss (Matama-Kauma *et al*., 2007). The egg parasitoid *Telenomus busseolae* Gahan (Scelionidae) caused parasitism of up to 46 % on *B. fusca* eggs in Uganda in a study by Matama-Kauma *et al*. (2007). Furthermore, *Telenomus isis* Polaszek, which was reported from western Africa, as well as the Asian trichogrammatid *Trichogramma chilonis* Ishii have been recommended for introduction into eastern Africa and Uganda respectively (*ibid*).

2.3.6 Vegetable and fruit pests and diseases

Aphids are members of the large family *Aphididae* and are especially harmful due to their rapid rate of reproduction, their frequent ability to carry virus disease and the effect of their sucking damage on the growth of plants (Pury, 1968). The major species of aphids in Africa attack bananas, black beans, peas, fruit trees, vegetables, groundnuts, cotton and cereal crops (IB, 2011b). Their feeding can cause rolling, twisting or bending of leaves and heavily attacked plants can turn yellow and eventually wilt (*ibid*). They excrete honeydew which is a favourite food of black ants, which protect the aphids from their natural enemies (*ibid*). Aphids have a complicated life cycle, in which females can reproduce with or without mating (*ibid*). Young aphids become adults in one week, thus their numbers can increase rapidly (*ibid*). Adults may be wingless or winged and their colour can vary from black, green, red or other colours (*ibid*). They live in colonies on leaves and stems, preferably young shoots and leaves (*ibid*).

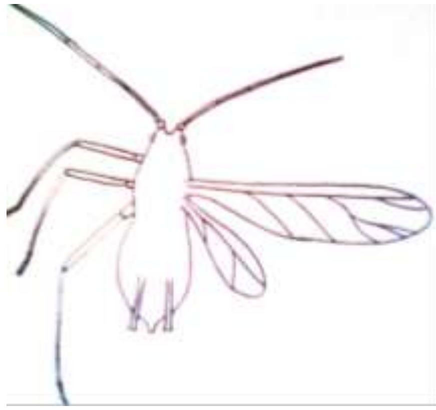

Figure 8: Adult winged aphid (Pury, 1968)

Figure 9: Maize plant infested by aphids (Picture: Johanna Unger)

Possible cultural practices to control aphids suggested in the literature are monitoring and field sanitation and management (IB, 2011b). Regular monitoring is recommendable as aphid populations can multiply rapidly (*ibid*).The undersides of leaves and bud areas can be examined for aphid colonies or ants, which may indicate the presence of aphids (*ibid*). It is possible to use monitoring traps, for example yellow sticky traps (IB, 2011b; IB, 2012b). Furthermore, the presence of natural enemies should be recorded (IB, 2011b). Economic damage treshold levels depend on many factors such as crop stages, crop age, economic and climatic conditions (*ibid*). It is thus recommended to monitor the aphid population within three to five days and plan treatments if a rapid growth is observed (*ibid*). Field sanitation includes the maintenance of crop health, the practice of crop rotation and mixed crops and the cultivation of trap crops, such as dill, nasturtiums or timothy grass (*ibid*). Onion (*Allium cepa*), chives (*Allium schoenoprasum* L.), garlic (*Allium sativum*) and Mexican marigold (*Tagetes minuta* L.) have been found to repel aphids and the intercropping of beans with maize has proven effective against black bean aphids (*ibid*). Aphids are usually highly susceptible to rain, thus their populations usually peak during the dry season and mulch can be used as a prevention measure (Pury, 1968). Excess use of manures and fertilisers produces fleshy plant tissue attractive to aphids and should thus be avoided (IB, 2011b).

In Uganda, groundnuts are additionally attacked by several species of thrips (IB, 2012f). The flower thrips (*Frankliniella schultzei* Trybom and *Megalurothrips sjostedti* (Trybom)) mainly infest buds and flowers, while other species of thrips (e.g. *Scirtothrips dorsalis* Hood and *Caliothrips indicus* (Bagnall)) infest foliage (*ibid*). They cause yellowish-green patches on the upper leaf surface, brown necrotic areas and silvery sheen on the lower leaf surface and leaves become thickened and curled (*ibid*). They can be controlled by natural enemies such as predatory thrips, lacewings and predatory bugs (*ibid*). The crop can also be sprayed with botanicals such as extracts from garlic, rotenone, neem (*Azadirachta indica*) or *pyrethrum* (*ibid*). It is recommended to plough and harrow before transplanting in order to reduce thrips attacks by killing the pupae in the soil (*ibid*).

Cutworms (*Agrotis segetum* Denis & Schiffermüller and others) belong to the order *Lepidoptera* and family *Noctuidae*. Their larvae (caterpillars) attack the stems of young or seedling plants at ground level, for example maize, cotton, cabbage (*Brassica oleracea* L.), beans, coffee and tobacco (*Nicotiana tabacum* L.) (Pury, 1968). *Agrotis ipsilon* is one of the most widely distributed cutworm species (IB, 2011c). Young caterpillars feed on foliage while older caterpillars are more likely to be found on stems (Pury, 1968). They may cut completely through the stem or just cause the plant to fall over (*ibid*). External feeding on leaves by young caterpillars results in the presence of tiny 'window panes' and can lead to falling leaves, while feeding on stalks and stems results in small holes found on stems and roots near the soil surface (IB, 2011c). Mature caterpillars are capable of destroying the entire plant (*ibid*). Eggs are preferably laid in damp, low-lying areas and hatch in ten to 28 days (*ibid*). Young caterpillars are pale, yellowish-green with a blackish head (*ibid*). Older caterpillars are nocturnal and pupate in an earthen cell in the soil (*ibid*). The adult is a medium-sized moth which is also active at night (*ibid*).

Figure 10: Cabbage attacked by caterpillars (Picture: Johanna Unger)

Cutworms tend to be more frequent in soil with plenty of decaying organic material and damage is worse where cutworms are present in large numbers before planting (IB, 2011c). They often reoccur in the same field if crop residues and dense stands of weeds are present (*ibid*). Thus, fields should be checked before sowing or transplanting and vegetation and weeds should be destroyed ten to 14 days before planting (*ibid*). Caterpillars should be monitored at dawn and hand-picked at night or in the very early morning (*ibid*). Moths can be monitored by pheromone traps (*ibid*). Ploughing can expose caterpillars to predators and desiccation by the sun and flooding of the field can help kill caterpillars in the soil (*ibid*). The most important natural enemies are parasitic wasps such as *Cotesia (Apanteles) ruficrus* (Haliday) and *Snellenius manilae* Ashmead, flies such as the tachinid fly and predators such as ground beetles, lacewings, praying mantis, ants and birds (*ibid*). Confining hens on garden beds prior to planting can be very effective (*ibid*). Neem (*Azadirachta indica*) can be used as a biopesticide, for example by spraying neem leaf extracts three times at weekly intervals (*ibid*). Physical methods include bait traps which consist of flour, water and insecticide, protective collars for plants, sticky substances placed around the plants, ashes spread on seedbeds or around plants and sticks as mechanical barriers (*ibid*).

The class *Nematoda* belongs to the phylum *Helminths* (worms) and thus are invertebrates, but unlike the *Arthropoda* they are legless (Pury, 1968). *Nematoda* can both be animal parasites and plant-feeding worms, and there are also a large number of non-parasitic, free-living worms (*ibid*). In East Africa, the most important plant-feeding worms are the root knot eelworms (*Meloidogyne incognita* (Kofoid & White)) and the leaf eelworms (*Aphelenchoides* ssp. Fischer) (Pury, 1968; IB, 2011e). The most common root knot eelworms are *Meloidogyne spp* which attack particularly plants of the family *Solanaceae* Juss. but also a variety of other horticultural crops, especially common bean (*Phaseolus vulgaris*) and cowpea (*Vigna unguiculata* (L.) Walp), but also tomato (*Solanum lycopersicum* L.), aubergine (*Solanum melongena* L.), okra (*Abelmoschus esculentus* Moench), cucumber (*Cucumis sativus* L.), melon (*Cucumis spp.* L.), carrot (*Daucus carota* subsp. *sativus* (Hoffm.) Schübl. & G. Martens), gourds (*Lagenaria spp.* Ser.), lettuce (*Lactuca sativa* L.) and peppers (*Capsicum* spp. L.) (*ibid*). The worms damage the roots of their hosts through internal feeding and cause lumps to form on the roots (Pury, 1968). They are most likely to attack in impoverished soils common in over-cultivated areas (*ibid*). Affected plants are stunted and yellow and have a tendency to wilt in hot weather (IB, 2011e). Plants may also die from heavy infestation (*ibid*). The female eelworm releases eggs near the root's surface and can survive up to seven years (Pury, 1968). Once a host plant is available, the larvae hatch, enter the root hairs and mature inside the root knots (*ibid*). When infested plants are pulled from the soil, the roots are distorted, swollen and have galls of 25 mm or more in diameter (IB, 2011e). Attack by nematodes may increase the severity of wilt diseases (IB, 2012c). *Meloidogyne* spp. also attack bananas, however, the burrowing nematode (*Radopholus similis* (Cobb) Thorne) is the most destructive nematode species attacking bananas (*ibid*). Infestation is indicated by dark patches or spots on the roots or even stubs of rotted roots and may cause plants to fall down (*ibid*).

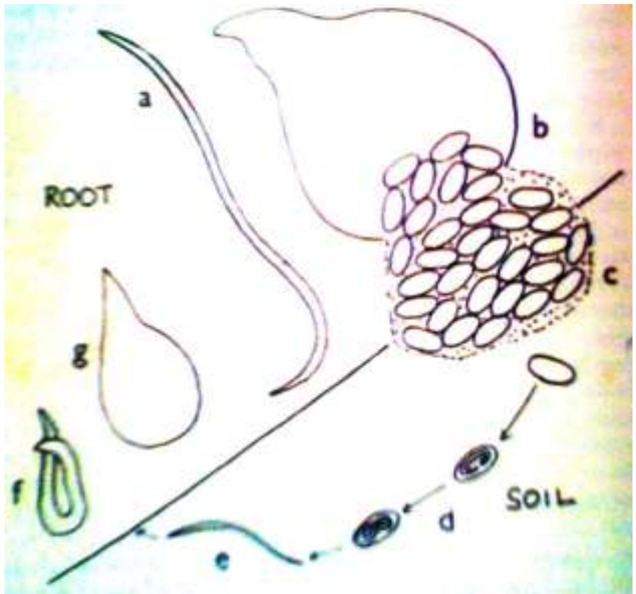

Figure 11: Life cycle of Meloidogyne ssp.: a) mature male b) mature female c) egg mass d) eggs maturing in soil e) infective larva f) immature male g) immature female (Pury, 1968)

Figure 12: Banana plant affected by nematodes (picture: Johanna Unger)

Root knot nematodes are soil inhabitants and thus spread by transplanting infested seedlings, soil washed down slopes or sticking to farm implements and farm workers or by irrigation water (IB, 2011e). The disease is most serious on light, sandy soils and in furrow irrigated areas. Thus, high levels of organic matter should be maintained in the soil through manure and compost (IB, 2012c). Infected volunteer plants, monocultures, weeds and continuous cropping may additionally favour the development of this pest (*ibid*). It is therefore recommended to apply crop rotation, especially planting a susceptible crop such as tomato before a tolerant crop such as cabbage, to be followed by a resistant crop such as onions (*ibid*). Furthermore, trap crops such as marigold (*Tagetes* spp) and Indian mustard can be used and destroyed once they have attracted the pest or they can also be used as intercrops (*ibid*). Furthermore, the application of neem cake powder into the soil, the solarisation or biofumigation of seedbeds and the uprooting of entire plants after harvest are recommended (*ibid*). For tomatoes, resistant varieties are available and the infestation of banana with *Radopholus similis* can be avoided by low-cost tissue culture produced in laboratories (IB, 2012c; RST, 2013).

Whiteflies (*Bemisia tabaci* (Gennadius) and *Trialeurodes vaporariorum* Westwood) are important pests of beans and both the larvae and the adults cause reduced plant growth, yellowing of leaves and wilting of the plants (IB, 2012h). They produce honeydew which can cause mould on leaves and pods (*ibid*). Infestations only affect yields when they happen before the onset of flowering (*ibid*). They can be managed by conserving parasitic wasps and spraying the crop with neem products (*ibid*). Control measures are only necessary in the case of large attacks during early stages of the crop (*ibid*).

The main diseases affecting cassava are African cassava mosaic virus (ACMV), cassava bacterial blight, cassava anthracnose, and root rot (IB, 2012g). The African cassava mosaic virus is spread through infected cuttings and by whiteflies (*Bemisia tabaci*) and can cause yield reductions of up to 90 % (*ibid*). Mosaic patterns on the leaves at an early stage of leaf development are the most characteristic symptom, however, the symptoms can vary between different plants in the same location (*ibid*). It can be best managed by using disease-free cuttings or selecting stem cuttings from the branches instead of the main stem (*ibid*). Furthermore, resistant cultivars are available (*ibid*).

Fruit flies occur in all African countries with the Mediterranean fruit fly *(Ceratitis capitata* Wiedemann*)* being the most widely distributed one, which causes damage to a wide range of crops (IB, 2012e). The Mango fruit fly (*Ceratitis cosyra* Walker) attacks mango, guava, sour orange, marula, wild custard apple and wild apricot (*ibid*). The African invader fly *(Bactrocera invadens* Drew, Tsura & White*)* is a new species introduced to East Africa which primarily attacks mango, but also tomato, banana, guava, marula and avocado (*ibid*). Fruit flies puncture the fruit skin to lay eggs and thus enable bacteria to enter the fruit, which cause rotting of the tissues surrounding the egg (*ibid*). After hatching, the maggots form galleries while feeding on the fruit flesh and make the fruit unsuitable for human consumption (*ibid*). Infested fruits can be distinguished from healthy ones as they turn yellow or orange prematurely (Pury, 1968).

Fruit flies can be managed through orchard sanitation, biological pest control and biopesticides or physical methods (IB, 2012e). Fruits with dimples or oozing sap should be removed before falling to the ground to prevent maggots from leaving the fruits and pupating (*ibid*). This should be done twice a week during the season to be effective (*ibid*). The fruits can be fed to animals, burnt, exposed to the sun in black plastic bags or buried at least 50 cm deep (*ibid*). Major natural enemies of fruit flies are parasitic wasps and predators such as rove beetles, weaver ants, spiders and birds and bats (*ibid*). Tiny wasps (e.g. *Bracon* spp.), which parasitise the maggots of fruit flies, can be attracted by flowering crops such as dill (*Anethum graveolens* L.), parsley (*Petroselinum crispum* (Mill.) Fuss), yarrow (*Achillea millefolium* L.), zinnia (*Zinnia* spp. L.), clover (*Trifolium* spp. L.), alfalfa (*Medicago sativa* L.), cosmos (*Cosmos* spp. Cav.), sunflower (*Helianthus* spp. L.), and marigold (*ibid*). *Pyrethrum* solution and neem (*Azadirachta indica*) can be used as biopesticides and should be sprayed every five days after the beginning of flowering and in late evenings to avoid damage to bees (*ibid*). Lastly, fruit fly traps and fruit bagging can be used as physical methods (*ibid*). The "Lynfield trap", for example, can be made from plastic bottles or buckets filled with attractants such as methyl eugenol, protein hydrolysates, yeast, and pieces of fruit or vinegar (*ibid*). It should be hung two to four metres above the ground in a semi-shaded spot and in the upwind part of the canopy (*ibid*). Several traps should have a distance of ten to 50 metres and catches should be collected weekly (*ibid*).

Sugared baits which consist of a mixture of sugar and insecticides may also be used (Pury, 1968). Bagging is a laborious, but cheap and reliable method practicable on small trees which prevents fruit flies from laying eggs on the fruits and also protects from mechanical injuries (IB, 2012e). They can be made from newspaper or dried plant leaves and work well with melon, bitter gourd (*Momordica charantia* L.), mango (*Mangifera* spp. L.), guava (*Psidium* spp. L.), star fruit (*Averrhoa carambola* L.), and banana (*ibid*). Mango fruits should be bagged when the fruits are the size of chicken eggs (*ibid*). If plastic bags are used, they should have a few small holes to prevent trapping of moisture and they be disposed of properly after harvest (*ibid*).

2.3.7 Storage pests

Storage pests are one of the main causes of food insufficiency in East Africa (IB, 2012d). Insect damage mostly occurs through weight loss of the crop, removal of the palatable parts of the grain and tainting of the food (Dunbar, 1969). Infestation is favoured through temperatures from 27 to 31°C, a moisture content of 12-18 % and a relative humidity of 75-85 % (*ibid*). Rodents such as mice and rats carry diseases and thus contaminate more than they eat (*ibid*). Contamination by fungi such as species of *Aspergillus* spp. Micheli and *Penicilium* spp. Link poses a threat to human and animal health due to their production of mycotoxins (*ibid*).

The two groups of insects which attack grains and other commodities are *Coleoptera* and *Lepidoptera* (Dunbar, 1969). In the tropics, maize weevils (*Sitophilus zeamais*) and rice weevils (*Sitophilus oryzae*) are most common amongst the *Coleoptera* (Dunbar, 1969; IB, 2012d). In Uganda, they breed in maize, wheat, sorghum, rice, shea butter nut (*Vitellaria paradoxa* C.F.Gaertn.), dried sweet potatoes, dried cassava, beans, tepary beans (*Phaseolus acutifolius* A. Gray) and cowpeas (Dunbar, 1969). They often attack the crops in the field and their population builds up rapidly when grains are brought into store (*ibid*). Females lay eggs into the grains which hatch into larvae in 4-5 days and develop further into pupae after three more weeks, which develop into adults within a few days (*ibid*).

The red flour beetle (*Tribolium castaneum* Herbst) breeds in flour and maize meal ("posho" in local language) in Uganda, but also in sorghum, rice, groundnuts and other products (Dunbar, 1969). It has a life cycle of 5-6 weeks and infestation leads to persistent unpleasant odours of the products (Dunbar, 1969; IB, 2012d). The bean bruchid (*Acanthoscelides obtecus* Say) is the most common pest of beans in Uganda with a life cycle of 4-5 weeks (Dunbar, 1969). Other storage pests are cowpea bruchids

(*Callosobruchus maculatus* (Fabricius)), the larger grain borer (*Prostephanus truncatus* (Horn)), the lesser grain borer (*Rhizopertha dominica* (F.)), the Angoumois grain moth (*Sitotroga cerealella* (Olivier)) which breeds in paddy, maize, millet, sorghum and wheat, the Khapra beetle (*Trogoderma granarium* Everts) which was introduced from South Asia and dried fruit beetles (*Carpophilus* spp.) which only attack broken or damaged grain (Dunbar, 1969; IB, 2012d). The potato tuber moth (*Phthorimaea operculella* Zeller), which has been introduced from South America, is the most serious pest of potatoes in the region and its caterpillars attack also tobacco, eggplants and tomatoes (IB, 2012d).

Storage pests can be controlled through various measures according to the literature. The appropriate construction of store buildings can prevent the exposure of grains to rain, humidity and rodents (Dunbar, 1969). A good seed store must be airy, shady, cool and dry (IB, 2012d). Temperature variations should be avoided as they encourage water condensation, which may promote fungal development (*ibid*). Store hygiene can be achieved by sweeping floors, keeping stock above floor level and disinfection (Dunbar, 1969). Furthermore, stocks should be rotated so that the first produced brought into the storage will be the first used (*ibid*). Different types of produce should be stacked in separate piles and only new or cleaned old gunny bags should be used (*ibid*). Insecticides commonly used are contact insecticides such as malathion and fumigants, which have no residual effect (*ibid*).

Local methods of control are mixing ash with grains, thorough drying, hanging cobs and heads in smoky places, storage in raised granaries and storage of groundnuts in bundles (Dunbar, 1969). Drying is usually done by spreading seed out in the sun on a hard clean surface for several days (IB, 2012d). It has been found that modern, high-yielding varieties of maize may be more susceptible to storage pests, thus, choosing indigenous seeds is highly recommended (*ibid*). Wood ash alone or mixed with powdered chilli pepper (*Capsicum frutescens* L.) is an efficient method of pest control, however, ashes may have an effect on the taste of the product, and they do not control the larger grain borer (*ibid*). Mixing seeds with 0,3 % lime has proven successful in weevil control and big seeds can also be mixed with sand (*ibid*). Plants which have been used to protect seed are A*loe vera (*L.) Burm.f., chilli peppers (*Capsicum* spp. L.), *pyrethrum*, sunnhemp (*Crotolaria juncea* L.), thorn apple (*Datura stramonium* L.), Derris *spp. Lour.*, *Eucalyptus* spp. L'Hér., *Lantana* spp. L., Syringa (*Melia Azedarach* L.), Mexican Marigold (*Tagetes minuta*), spearmint (*Mentha spicata* L.) and neem (*Azadirachta indica*) (*ibid*). Generally, around 50 g plant substance per kg of stored product should be applied (*ibid*).

2.4 Indigenous knowledge

While in the 50s and 60s, indigenous knowledge was seen as an obstacle to development, the promise it holds for agricultural production systems and sustainable development is nowadays recognised (Agrawal, 1995). It was found that "'development from below' is for many reasons, a more productive approach than that from above, and [...] an essential ingredient is indigenous knowledge" (Brokensha *et al*., 1980). The Declaration on Science and the Use of Scientific knowledge observes that "traditional and local knowledge systems as dynamic expressions of perceiving and understanding the world, can make and historically have made, a valuable contribution to science and technology, and that there is a need to preserve, protect, research and promote this cultural heritage and empirical knowledge." (ICSU, 2002)

Nakashima *et al*. (2012) define indigenous or traditional knowledge as 'the knowledge and know-how accumulated across generations, and renewed by each new generation, which guide human societies in their innumerable interactions with their surrounding environment'. Other terms for this knowledge include traditional ecological knowledge (TEK), farmers' knowledge, folk knowledge and indigenous science (Nakashima *et al*., 2012). Another term used is local knowledge. It is a more general term which embraces a larger body of knowledge systems and includes those classified as traditional, indigenous and rural (FAO, 2005). "Local knowledge is not confined to tribal groups or to the original inhabitants of an area. It is not even confined to rural people. Rather, all communities possess local knowledge - rural and urban, settled and nomadic, original inhabitants and migrants" (FAO, 2005).

Other than in occidental cultures, in indigenous worldviews, the scientific knowledge is not presented in opposition to practice and the spiritual, but instead combined in a holistic understanding of interaction with the surrounding environment, such as social organization and institutions and spirituality, rituals, rites and worldview (Nakashima *et al*., 2012). Indigenous knowledge is closely interwoven with cultural values, locally specific, rather tacit or implicit than explicit, not recorded and rather anecdotal than verified (Hofny-Collins, 2013, pers. comm., 24 Jan.). At the same time, the distinction between indigenous and western knowledge had been questioned, and a productive dialogue about who will benefit from the dissemination of knowledge has been pointed out as more important (Agrawal, 1995). Similarly, views which accord women a privileged status in indigenous systems have been described as unsustainable due to the facts that women may possess particularly rich insights about some aspects of their culture in all civilizations, and at the same time, they are excluded from particular knowledge in many indigenous cultures (*ibid*).

According to the World Bank Indigenous Knowledge Programme, indigenous knowledge systems are at risk of becoming extinct and their preservation plays an important role as they provide problem solving strategies especially for the poor and represent an important contribution to global development knowledge (Worldbank, 2014). The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) has stated that that realizing its development and sustainability goals - the reduction of hunger and poverty; the improvement of rural livelihoods and human health; and facilitating equitable, socially, environmentally and economically sustainable development - requires acknowledging the multifunctionality of agriculture as well as the integration of local and traditional knowledge (IAASTD, 2009). An environment in which formal science and technology and local and traditional knowledge are seen as part of an integral agricultural knowledge system is expected to have the potential to increase equitable access to technologies for a broad range of producers and natural resource managers (*ibid*).

Traditional and local knowledge was also acknowledged in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) as 'an invaluable basis for developing adaptation and natural resource management strategies in response to environmental and other forms of change' (IPCC, 2007). Indigenous peoples are particularly exposed to climate change due to their resource-based livelihoods, isolation and the absence of rights over their territories (Nakashima *et al*., 2012). In spite of this, they have demonstrated resourcefulness and resilience in the face of climate change and their knowledge is specifically essential for climate change adaptation due to its focus on elements of significance for local livelihoods, security and well-being (*ibid*). An important source of resilience for indigenous people is their ability to nurture biodiversity, as genetic diversity provides security to farmers against pests, diseases, droughts and other stresses (Nakashima *et al*., 2012; Koohafkan, 2011). According to Koohafkan (2011), there could be much progress in pest management schemes if the biological mechanisms within the structure of traditional agroecosystems can be determined.

2.5 Chemical pesticides

The agrochemical revolution has its origin in the Second World War, when herbicides were developed as a by-product of warfare research and a high capacity for the production of biocides was created by developing insect-fighting weapons (Vandermeer, 2001). When the chemical industry faced an overproduction crisis, it developed marketing strategies in post-war U.S. and Europe by translating the need of the chemicals to "defeat the enemy in war" into the need for the same chemicals to "defeat the new enemy in agriculture" (Vandermeer, 2001). The negative effects of the massive use of pesticides on the environment were first pointed out by Rachael Carson in 1962 with her book "Silent Spring" (Vandermeer, 2001). Since then, her predictions have not only come true in many parts of the world, but further problems have emerged such as industrial accidents in pesticide manufacturing plants, as for example the Bhopal disaster in 1984 which killed thousands of local people in India (*ibid*).

The problems of chemical pesticides have also been known in East Africa since long and were for example already described in 1968 by J.M.S. de Pury. He similarly refers to the risks of resistance, of killing beneficial insects and of affecting human and animal health. Local magazines for farmers promote indigenous methods and create awareness of the risks of chemical pesticides. In Vol. 4 of the Uganda Environews, for example, it is described that chemicals kill useful insects which may naturally manage pests, that they can be harmful to human health through consumption of treated crops, stay in the environment and bodies of animals for many years and that pests may develop resistance against them over few breeding cycles (UNDP, 1997). However, the problem remains that agricultural development policies have been successfully emphasising external inputs as the means to increase food production during the past fifty years, and they continue to do so in most parts of the world (Pretty & Röling, 1997). Thus, it is these policy frameworks which pose one of the principal barriers to a more sustainable agriculture (*ibid*).

2.6 Agricultural extension

The term "extension" derives from an educational development in England during the second half of the 19th century, where universities tried to find ways of serving the educational needs of the rapidly growing population in the urban area (Jones & Garforth, 1997). By the 1890s agricultural subjects were being covered by lecturers in rural areas (*ibid*). Agricultural extension has evolved over nearly four thousand years, but its modern forms are largely a product of the past two centuries (*ibid*). In most tropical African countries, the European interaction with the native agriculture was minimal before 1914, and after colonial territories gained their independence, extension work has been staffed by nationals, mostly under the patronage of ministries of agriculture (*ibid*). During the past quarter century, strong efforts have been made in the less developed countries to benefit the small farmers through the training and visit system (*ibid*).

The major organisations providing extension services in Uganda are public sector institutions, private companies, non-governmental organisations (NGOs), farmers associations and community-based organizations (IFPRI, 2013). From the side of the government, the main body for extension is the National Agricultural Advisory Services (NAADS). In the scope of recent reforms, many functions and responsibilities for the implementation of agricultural extension services have been transferred from the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) to local district governments (*ibid*). The privatisation and liberalization of service delivery has furthermore attracted more NGOs to offer services (*ibid*).

Chambers & Jiggins (1986) suggest that the farmer-first-and-last (FFL) model fits the diverse and complex needs of resource-poor farmers much better than the traditional transfer-of-technology (TOT) model and its associated training and visit system of agricultural extension. The FFL model implies that scientists learn from resource-poor farmer families, their resources, needs and problems (Chambers & Ghildyal, 1985). The normal TOT, by contrast, is a linear, top-down model with a one-way information flow where the agricultural extension service is charged with the responsibility of transferring the research findings from universities and research stations to farmers (Chambers & Jiggins, 1986). The training and visit system has revealed the lack of adoptable advice for extensionists to pass on to farmers and thus pointed to the irrelevance of much agricultural research (*ibid*). Farmers have several advantages over scientists (*ibid*). Firstly, their knowledge of the whole farming system enables them to take a broader view of the implications of technical change than a scientist (*ibid*). Secondly, their adaptations to climatic and physical factors are hard to reproduce in on-station conditions (*ibid*). Thirdly, farming is a highly time-driven activity and thus, farmers' knowledge is adapted to variable environments and economic conditions (*ibid*). Lastly, there is an increasing recognition of the capacity of smallholder farmers to be active experimenters (*ibid*). In spite of all this, four forces operate to maintain the TOT model, which are education and training, government and commercial funding, research methodology, and professional and personal incentives (*ibid*). Research on chemical pesticides and fertilisers is funded by both governments and commercial organisations, and the research is predominantly for crops which are marketed (*ibid*). Similarly, the reductionism of normal agricultural research fits the simplifications of commercial farming (*ibid*). Lastly, agricultural scientists are rewarded for their publications, and financial incentives draw scientists to work on crops of major marketing importance (*ibid*). Thus, blaming farmers for the failure of the TOT model is a negative defence, which denies any need to change the research process (*ibid*).

According to Pretty & Röling (1997), there are three major lessons for extension. First, it is important to make visible the state of the environment and the extent to which present farming practices are untenable (Pretty & Röling, 1997). Extension can demonstrate the feasibility of sustainable practices and give farmers tools for observation and monitoring of the situation on their own farms (*ibid*). Secondly, farmers' knowledge should be used and indigenous practises which have been lost due to the impact of chemical farming need to be revived (*ibid*). Lastly, instead of transferring technology, extension workers should put an emphasis on facilitating learning, for example through creating learning groups (*ibid*). Chambers & Jiggins (1986) stress the importance of a clarifying dialogue between scientists and farmers, for which scientists need to change from considering their knowledge superior to that of farmers to being willing to learn from them.

3. Research questions

The overarching research question of this thesis is how local knowledge is applied by farmers towards management of crop pests and diseases in the Masaka region, Uganda. This question was subdivided into several more specific questions, which were partly changed and adapted during the course of the field research. Furthermore, additional research questions were included as the research progressed. While the first three research questions asked for and achieved rather straight-forward answers and results, the last three questions required deeper enquiries and led to more complex findings. However, none of the questions aimed at a quantitative analysis, and all of them are for the site-specific conditions.

1) What are the main pests and diseases to be dealt with in the Masaka region? What are the main crops affected and how/when are they affected?

This research question aims at obtaining an overview of the present situation in terms of pests and diseases in the region as well as uncovering problems related to this topic and specific to the current generation and researched area.

2) What are the main indigenous methods of pest and disease management in this region?

This question is targeted at collecting and documenting traditional knowledge about pest and disease management in the Masaka region, distinguishing between different methods and their prevalence and estimating the proportion of traditional methods versus chemical methods.

3) How effective are the methods applied by local farmers for pest and disease management?

The aims of this question are to know the farmers' assessment of their methods, to make out their motivation for using their methods and to estimate the effectiveness of their methods as they apply them.

4) Where does the knowledge of farmers about pest and disease management mainly come from?

This question targets at investigating the sources of knowledge for farmers, assessing the value and relevance of these sources, distinguishing between the types of knowledge provided by these sources and discovering possible reasons for a lack of knowledge of farmers.

5) What are the opinions of farmers and advisors about chemical pest management?

The aim of this question is to estimate the degree of the farmers' awareness of the implications of the use of chemical pesticides, to identify reasons for a neglect of traditional methods in favour of chemical methods and to estimate the extent to which the problems of the use of chemicals are brought to the farmers' attention.

6) What are the possibilities for farmers to improve / extend their knowledge about pest and disease management?

This research question aims at exploring the most prevalent needs of the farmers in terms of knowledge specifically about pest and disease management, and possibilities to fulfil their demands.

4. Methodology

As described by Harwell (2011), a research study's methodology is usually described as qualitative, quantitative or as involving mixed methods. Qualitative research methods, which are used for this thesis, focus on discovering the experiences and thoughts of participants and on making sense of phenomena in terms of the meanings people bring to them (Hiatt, 1986; Denzin & Lincoln, 2005). The researcher collects information through methods such as case studies, ethnographic work and interviews and may construct hypotheses from his findings, which entails that he or she cannot pretend to be objective (Harwell, 2011). Qualitative research does not aim at replicability and generalizability due to the unique interactions among participants and researchers as well as the open research process (*ibid*).

This research was based on a case study approach aimed at exploring the context specific situation in relation to farmers' and local agricultural support staff's perceptions of pest and disease related problems. As such, a constructivist point of view was taken in the awareness that researchers design studies based on what they believe knowledge to be, facing the question of whether there is an objective reality which they can discover, or whether the world is a product of the imagination constructed in the minds of individuals and groups (Bean, 2005). Furthermore, "the selection of topics for study is neither innocent nor rational. It is not innocent, because being selected gives a topic legitimacy, creates the power of knowledge for those affected by the topic, and creates invisibility for those excluded. It is not rational, because researchers choose topics to study based on professional interests, not professional mandates, and on self-interest based on what researchers value, are curious about, or perceive they will profit from." (Bean, 2005)

Some of the research questions developed through the course of the research, and similarly, the questions asked to the advisory staff from organisations and the government were adapted after retrieving information from the farmers interviews. Two issues gained relevance through the course of obtaining the first results. On the one hand, they refer to the origin of local knowledge, on the other hand they refer to knowledge transfer both between farmers themselves and between farmers and the government extension service, non-governmental organisations and researchers. Furthermore, the questions of how farmers knowledge can be improved and to which extent and why chemical pesticides are used were found worth investigating in context with the original research questions. In this regard, the research design followed aspects of action research, such as a flexibility allowing adaptations and changes in focus (McNiff, 2002). However, it did not follow the aspects of changing and improving the situation beyond mere observation, nor of active participitation and self-reflection of the researcher (*ibid*).

The research used a qualitative methodology based on interview methods used in participatory rural appraisal (PRA). The principles of PRA of 'handing over the stick' to local people, 'using one's own best judgement at all times', a multi-way sharing of ideas and information and the stimulation of 'community awareness', are seen as a pre-requisite of appropriate technology and sustainable development (Chambers, 1992). According to Pretty (1995), the term 'participation' has become fashionable with many different interpretations and should not be used without clarification.

This was a relatively short research study and as such meaningful participation, which requires an on-going co-learning process (Pretty, 1995), was never possible, nor intended. Rather, principles of PRA were applied in the information gathering process in order to encourage people to talk freely about their practices and perceptions.

The main tools used for this research were semi-structured interviews and focus groups, which belong to the class of methods for interviewing and dialogue, one of the classes of participatory methods for alternative systems of learning and action (Pretty *et al*, 1995). The details of how the tools were used for this research are elaborated in the following sections.

4.1 Semi-structured interviews

Semi-structured interviews can be defined as "guided conversation in which only the topics are predetermined and new questions or insights arise as a result of the discussion and visualized analyses" (Pretty *et al.*, 1995). Key skills for conducting the interviews are a good team preparation, awareness of the interview context, sensitive questioning, sensitive listening, judging and cross-checking responses, a detailed recording of the interviews, additional observations, follow-up notes of personal impressions and self-critical review (*ibid*). If the local language is not known, a knowledgeable interpretor should be found (UNHCR, 2014). It should be considered in advance how many interviews can realistically be conducted within the available time and it should be kept in mind who is present during the interviews as this will affect what the respondents are willing to tell (*ibid*). The researcher should introduce him- or herself and inform the participants about the purpose of the research in the beginning (*ibid*). Open, generative questions should be asked first for each new theme, supplementary questions are used to probe for more detail and closed questions should be asked last to avoid a pattern of short responses (*ibid*). It is important to maintain an informal approach and not to interrogate, but to mix questions with discussion (*ibid*). Informants should be allowed to explain their points fully and to wander (*ibid*). The interviews carried out in this research were designed along these principles. To ensure a better trustworthiness of the findings, the criterium of triangulation was used by parallel investigations through focus groups and by interviews with people of professional and disciplinary backgrounds.

4.2 Focus groups

Focus groups are conducted to discuss a particular topic while recording people's reactions and can complement surveys by finding out why people feel as they do about something or the steps they go through in making decisions (Bernard, 2006). They are especially helpful to obtain information about content and process and have the advantage of internal discussions in which farmers can identify and specify their knowledge (Bernard, 2006; Chambers & Jiggins, 1986). Statistical analysis should not be performed on focus group data as samples are small, respondents are not selected using random sampling, questions are not administered in a standardized fashion and the information gathered is complex and important insights would thus be lost through coding the data for a statistical programme (PRA, 2014). For a good practice, participants should be selected who have knowledge and are willing to share it, the meeting must be positive, the group composition should be homogenous and participants must be informed of audio or video recording and observation (*ibid*). A semi-structured discussion guide should be used and it should be made sure that all participants contribute (UNHCR, 2014). The moderator must combine qualities such as imagination and logic, and eye for details and a conceptual ability, and analytical thinking and tolerance of disorder (R & D, 1979). A focus group should not attempt to cover too many questions and small groups of less than ten people work better than large groups; however, more than one focus group should be used (PRA, 2014). The combination of individual interviews and focus groups is recommendable due to the assets and drawbacks of both tools. For example, focus groups enable the participants to interact with each other, which can lead to more in-depth discussions, the dynamic environment allows the moderator to modify the topics and make them more suitable for the purpose and non-verbal behaviour can be perceived by the researcher (PBworks, 2006). On the other hand, there is the risk of a few people dominating the discussion, sensitive topics are less likely to be explored, and the participants may behave differently in the group setting than they would in their home environment (*ibid*). Further reflections on the experience of the chosen methods of working are presented in section 6.3.

5. Methods

The research for this thesis was conducted during a stay in Uganda for two months in June and July 2013. Semi-structured interviews were conducted in the Masaka region on seven different days with 43 farmers in seven different locations. Additionally, farmers were asked to discuss questions in focus groups in four locations. Field Officer Mr Kefa Kalanzi who has a BSc in Organic Agriculture from Uganda Martyrs University offered his service as a translator between English and Luganda. He furthermore helped to find out about farmers groups which could be visited, as he is from the region himself, and he also helped to reach the different locations. In some of the locations, farm walks were conducted and examples of pest and disease damage or management methods were pointed out by the interviewees. The questions for the interviews were devised in advance and adapted after consultation with co-supervisor Dr. Julius Mwine. The questions asked in the focus groups were oriented by the interview questions but kept more open-ended and also less in number due to the time frame. Discussions would often raise new questions, which would then be further discussed. Lastly, interviews were conducted with employees from non-governmental organizations (NGOs) and advisory staff from the government. These interviews were semi-structured and partly unstructured due to the different backgrounds of the interviewees and so as to enable them to freely share information and mention what seems most important to them personally. Furthermore, the questions were partly devised according to information obtained in the farmers interviews.The interviews were conducted in English which made no translator necessary. All interviews and focus group discussions were recorded both through written notes and a voice recorder and the notes were translated into digital form with the help of the programme Microsoft Excel. Over the whole period, literature was both collected and reviewed.

5.1 Interviews with farmers and focus groups

The locations for the individual interviews were selected according to the recommendations of Mr Kefa Kalanzi. One criterion was to attend farmers' groups meetings, which were the most suitable option in order to meet several farmers from different locations of the same area in one place, and to have the possibility to conduct focus groups at the same time. Furthermore, the locations selected had to be in reachable distance from Masaka town as the means of transport was public motorbikes.

The locations where farmers were interviewed were Kjabbogo Village in Kkingo sub-county, Kiteredde parish in Kkingo sub-county (three locations), Bugubira subparish in Mukungwe sub-county, Kisaaka village in Kkingo sub-county and Kasana parish in Kkingo sub-county. In locations where only interviews were conducted, the number of interviewees was eight to nine people. In locations where focus groups were to be held, usually only three to six individual interviews were conducted due to time restriction. In Bugubira subparish two farmers' groups were interviewed mostly in focus groups, Tukolere farmers' group from Bugabira itself and Abayitabriri group from Kisagazi parish. (See also Table 1)

Additionally, research was conducted while staying in the village Villa Maria in Kalungu disctrict, from where I also visited Katigondo seminary in order to interview former extension officer Joseph Mary Male.

Figure 13 shows a map of the Masaka district which was obtained from a map archive recommended by the Masaka Town council. Masaka municipality is in the centre and the research locations Kkingo sub-county, Mukungwe sub-county and Villa Maria are highlighted.

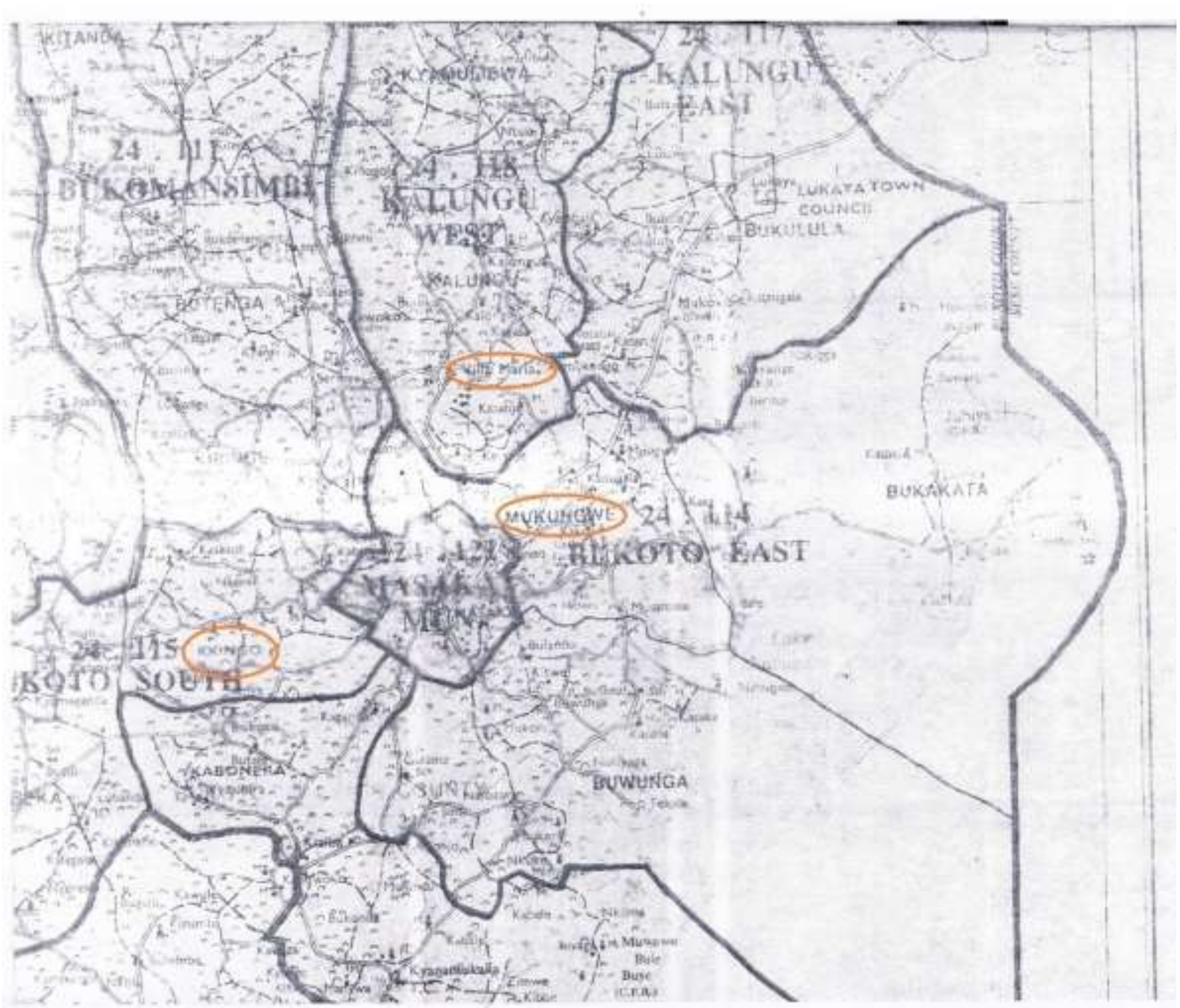

Figure 13: Map of the Masaka district with highlighted research locations

The questions asked in the interviews were as follows:

1) (Personal background and farm)
   a. What is your name and age?
   b. How big is your family? How many people work on the farm?
   c. What is the size of your farm?

d. Which crops are you growing on your farm?
e. What animals do you have on your farm & how many?
f. How do you use/sell your products?

2) What are the main pests and diseases to be dealt with on your farm (specific according to crop)? When do they occur and how would you estimate their impact on your yields? Since when have they been occurring?
3) Please describe your methods of pest and disease management and their frequency of use. How long have you been using them?
4) What are your methods of storage and what issues do you have with pests & diseases during the storage of your crops? How do you prevent them?
5) Describe your use of chemical pesticides. From where do you derive your knowledge about their application?
6) What is your opinion about chemical pesticides?
7) How effective are the methods applied by you for pest and disease management?
8) Where does your knowledge about pest and disease management mainly come from? Which knowledge did you receive from your parents?
9) Which advisory services have you used? What do you think about them?
10) Have you given your knowledge to other people and to whom? Do you take part in farmers' groups and in which ones? What can be reasons for a lack of exchange of knowledge?
11) What are the possibilities to improve / extend (your) knowledge about pest and disease management?
12) What do you think about the communication of knowledge from universities / science? How could the communication be improved?

Figure 14: Members of a farmers group interviewed in Bugubira subparish, Mukungwe sub-county (picture: Johanna Unger)

5.2 Interviews with advisory staff

In the following section the organizations of which staff members have been interviewed are shortly introduced.

Vi Agroforestry is a Swedish development cooperation organization which supports farmers in the Lake Victoria Basin in Eastern Africa (VI Agroforestry, 2013 a). Its mission is to contribute to poverty reduction, the right to food, increased incomes, increased biodiversity and climate adaption through agroforestry and to support farmers' organisations (VI Agroforestry, 2013 a). With climate change being one of the biggest threats to development in Africa, agroforestry can help to prevent erosion and bind carbon dioxide and at the same time, the methods enable farmers to increase and diversify their production (Vi Agroforestry, 2013 a; VI Agroforestry, 2013 b). In Uganda, Vi Agroforestry is working in the Masaka region (Vi Agroforestry, 2013 b). The target group consists of female and male small-scale farmers who are members or potential members of farmer's groups, associations or cooperatives (*ibid*). The "Farmers of the Future" programme is a regional programme teaching children in primary schools about sustainable farming (*ibid*). This does not only involve planting trees to contribute to the rehabilitation of impoverished soils, but also other methods such as improved water harvesting techniques (*ibid*).

The Uganda National Farmers Federation (UNFFE) is the largest non-governmental farmers' organisation in Uganda (EAFF, 2014). It was founded in 1992 with the objective of mobilizing the farming community and voices under one independent umbrella organization and to institutionalise competitions which are meant to reward best performing farmers in livestock and agricultural production (EAFF, 2014; Harms *et al.*, 2013). The Federation has 78 member farmer organisations and a total individual membership of over 1,000,000 farmers (Harms *et al.*, 2013). It strives to help farmers in four major areas - building institutions, technical assistance, general support services, and lobbying and advocacy (*ibid*). In 2011, UNFFE held a focus-group dialogue between NGOs, representatives of NAADS, farmers and researchers to assess the effectiveness of NAADS (*ibid*). Main constraints of NAADS were found to be the overpricing of inputs and provision of poor technologies to farmers, poor public relations at the local government level, a flawed selection process for model farmers which gave preference to rich or politically influential farmers and ineffectiveness in preventing the fall of annual growth in the Ugandan agriculture sector (*ibid*).

Kulika Uganda is an NGO which was established in 1981 in the UK and whose management was fully handed over to the Ugandan office in 2005 (Kulika Uganda, 2013a). Their core values are integrity, commitment, teamwork, respect and learning (Kulika Uganda, 2013c). They have developed their own programmes which target small holder subsistence farmers and students (Kulika Uganda, 2013a). Students are supported through a Scholarship Programme which supports more than 100 East African students per year and farmers are provided with trainings through a Sustainable Agriculture Training Programme which started in the mid-1990s (Kulika Uganda, 2013b; Kulika Uganda, 2013a). Amongst other projects, their Congregational Agricultural Development Programme (CADeP) provides agricultural training to members of religious communities so as to enable them to improve their livelihoods (Kulika Uganda, 2013d).

Send a Cow is a UK based international development charity with the mission of giving communities and families the hope and the means to secure their own futures from the land (Send a Cow, 2013a). They began working in Uganda in 1988, making it their longest standing programme (Send a Cow, 2013b). The massive depletion of the country's animal stock due to the civil war in the 1970s and 1980s led to a drop in crop yields and left the country with low-yielding, local cattle (*ibid*). Thus, Send a Cow provide families with dairy and cross-breed cattle along with training in animal care and the skills to integrate the livestock into a mixed farming system (*ibid*). Furthermore, they support families with orphaned children due to HIV as well as disabled people with their social development approach and they promote water conservation, woodland conservation and carbon sequestration through their environmental approach (*ibid*).

Heifer International is a global non-profit organization which was founded after the civil wars in the late 1970's and 1980's upon a request by the Church of Uganda to rehabilitate Uganda after the era of Idi Amin (Heifer, 2013 b). Their mission is to work with communities to end world hunger and poverty and to care for the earth (Heifer, 2013 a). They provide families with training and livestock and the families in turn share the training and pass on the first female offspring of their livestock to another family (*ibid*). This core concept is named as "Passing on the Gift" (*ibid*).

Even though no interview with a staff member of "**Caritas MADDO**" (Masaka Diocesan Development Organisation) could be conducted, the organisation shall be briefly explained as it was frequently mentioned by farmers. Caritas MADDO was started after the 1979 war and is a faith-based organisation offering social services and development work in Masaka Diocese (MADDO, 2013). Its mission is "to stimulate and direct sustainable development among the people of Masaka Diocese regardless of their political, tribal or religious affiliation." (MADDO, 2013) It is actively working in the political districts of Kalangala, Rakai, Ssembabule, Masaka, Kalungu, Bukomansimbi, Lwengo and Lyantonde and enters the communities through the church structure with its parishes, deanaries and sub-parishes (*ibid*). It also collaborates with the government ministries through the departments of Agriculture, Health, Water and Sanitation of the eight districts (*ibid*).

The persons interviewed were

- Victor Komakech and Matthias Masiga at the Swedish Cooperative Centre-Vi Agroforestry (SCC-Vi) Eastern Africa
- Joseph Mary Male who served as an agricultural field extension officer before taking over the management of the farm of the Katigondo National Major Seminary
- Kenneth Katungisa from the Uganda National Farmers Federation (UNFFE)
- Joseph Mugagga from Kulika Uganda
- Christopher Kyeswa and Claire Nsubuga Namutebi from Send a Cow Uganda
- Richard Wanyama from Heifer International.

Victor Komakech was interviewed at the Vi Agroforestry office in Masaka, Joseph Mary Male at his office in Katigondo Seminary, Kenneth Katungisa at the 21st National Agriculture and Trade Show which took place from 8th to 14th of July in Jinja, Joseph Mugagga in a personal meeting in Kampala and the members of Send a Cow and Heifer International at their respective offices in Kampala.

The questions asked were oriented by the following outline.

1) Please introduce yourself and your work field.

2) What problems do you see in today's pest and disease management?

3) From where do you / the extensionists derive your (their) knowledge about pest and disease management?

4) What do you think about traditional methods vs. chemical pesticides?

5) What are the main reasons for pests and diseases in this region?

6) Do you think the knowledge is spread between farmers? If not, why?

7) How are farmers' groups organized? What problems do occur in their organisation?

8) Which kind of exchange / collaboration do you have with other organizations / universities? How do you think the communication between farmers and universities could be improved?

6. Results

The following section is divided into two parts.

The first part presents the results of the interviews with individual farmers and of the focus group discussions. It contains information about the pest and disease problems faced by the farmers as well as their methods of combating them. After taking a look at the effectiveness of their methods as well as their opinions on chemical methods, the section ends with presenting the content of the farmers' statements on their access to knowledge and possibilities of improving their knowledge.

The second part presents the results of the interviews with staff from agricultural extension services and non-governmental organisations. It contains the statements and opinions of professionals in the agricultural advisory sector on their perception of the main challenges in pest and disease management in Uganda and particularly the Masaka region, and on the collaboration and knowledge-transfer between farmers and organisations.

6.1 Results from interviews with farmers and focus groups

6.1.1 Locations, respondents and farms

6.1.1.1 Locations and respondents

As outlined in Table 1, the interviews were conducted on seven different days with 43 farmers from seven locations. All locations were situated in Kkingo sub-county, apart from Bugubira subparish which was located in Mukungwe sub-county. Twenty-two of the interviewees were female and on one occasion a couple was interviewed. In the first location the husband and the wife of the same farm were interviewed. The average age of the interviewees was 52 years and 54,5 years, for female and and male interviewees respectively. The youngest interviewee was a 27 years old woman; the oldest person interviewed was a 82 years old man.

Table 1: Locations, dates and respondents of interviews and focus groups

Location	Date	Interviewees		Focus group
		male	female	
Kjabbogo Village, Kkingo sub-county	13-Jun-13	4*	4	-
Kiteredde parish, Kkingo sub-county	14-Jun-13	2**	7	-
Kiteredde parish, Kkingo sub-county	17-Jun-13	3	6	-
Mwalo village, Kiteredde parish, Kkingo sub-county	19-Jun-13	5	1	Yes
Bugubira subparish, Mukungwe sub-county	21-Jun-13	1	2	Yes (10 women, 3 men)
Kisaaka village,	25-Jun-13	5	-	Yes (8 men, 20

Kiteredde parish, Kkingo sub-county				women)
Kasana parish, Kkingo sub-county	26-Jun-13	1	2	Yes

*including a husband of a female interviewee
**1 male, 1 couple

6.1.1.2 Farm size and family size

Farm sizes ranged from 0,5 acres to 20 acres, with an average of 2,8 acres. The family size ranged from two to ten people, the average being six people. It was sometimes mentioned that some or all children came to the farm only during their holiday. One of the farmers stated that the family had five members but she was mostly managing the farm by herself. Generally the number of people working on the farm can be assumed to be lower than the family size. Only two of the farmers interviewed employed additional workers.

6.1.1.3 Crops and animals

1. Crops

The most common crops listed by the farmers were plantain (*Musa x paradisiaca* L.) (91 % of the respondents), beans (88 %), maize (88 %) and coffee (86 %). The next most common crop was cassava (35 %). Sixteen per cent of the respondents stated that they grew groundnuts, and 9 % also listed sugarcane (*Saccharum spp.* L.). Only one farmer listed yam (*Dioscorea spp.* L.). (Figure 15) One farmer explained in particular that she grew 20 coffee trees and 100 plantain trees on her 1 acre farm.

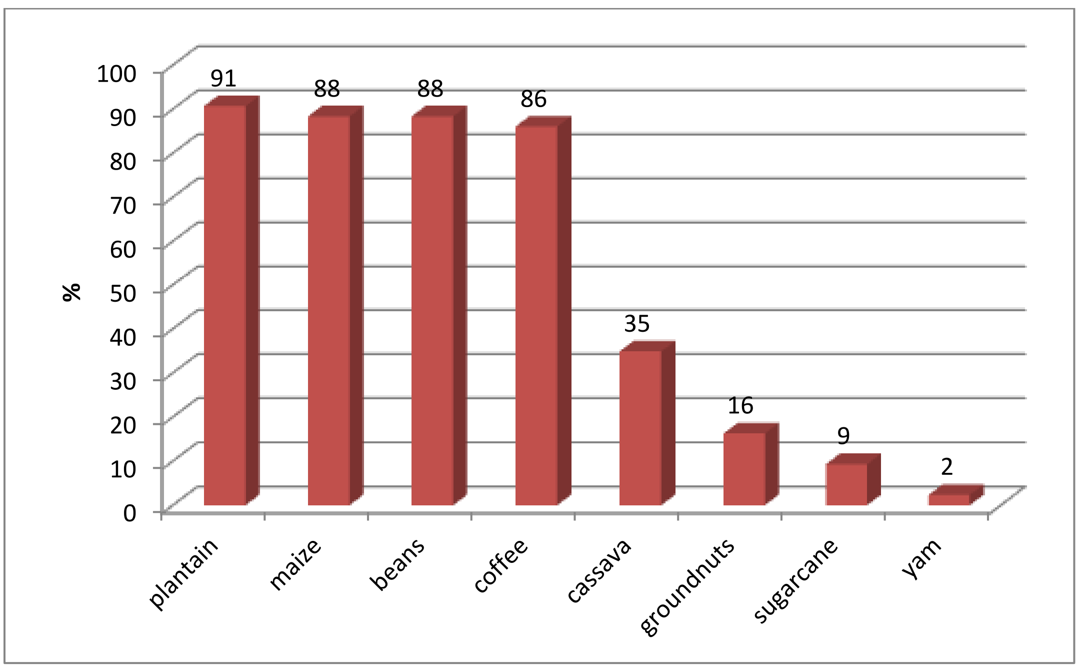

Figure 15: Main staple and cash crops grown by the farmers

The most common fruit tree listed was jackfruit (*Artocarpus heterophyllus* Lam.*)* (28 % of the respondents), followed by avocado (*Persea Americana* Mill.) (26 %), mango (12 %), sweet banana (7 %), papaya (*Carica papaya* L.)(5 %) and oranges (*Citrus x sinensis* (L.) Osbeck) (2 %). Nine per cent of the farmers mentioned that they had fruit trees without stating details. (Figure 16) It can be assumed that also farmers who did not state that they cultivate fruits had fruit trees for home consumption.

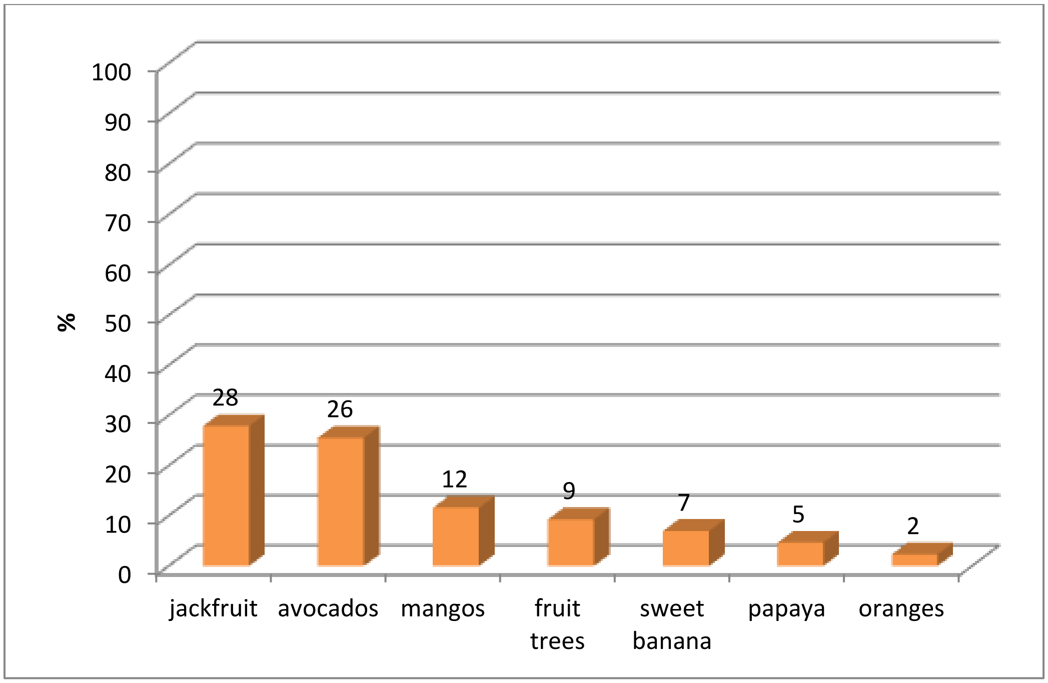

Figure 16: Percentages of farmers growing different fruits

Vegetable production was not very common in the area, only 19 % of the farmers stated that they grew vegetables in general. Sixteen per cent of the farmers listed sweet potato and 12 % listed Irish potato. Other vegetables listed were African eggplant (9 %), exotic eggplant (9 %), amaranth (*Amaranthus* spp. L.) (7 %), cabbage (7 %), tomatoes (7 %), sweet or green pepper (5 %), onions (5 %), squash (*Cucurbita* L.), carrots and spiderplant (*Cleome* spp, L.) (one respondent each). One farm had been specialised in onions and Irish potatoes for ten years. (Figure 17)

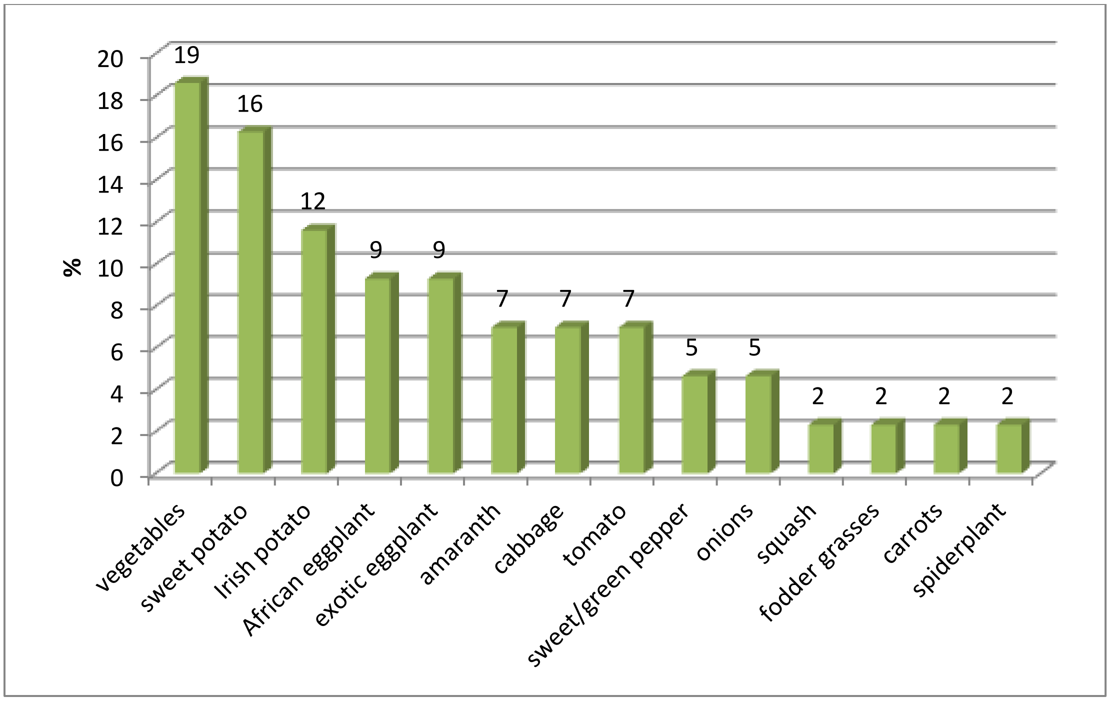

Figure 17: Percentages of farmers growing different vegetables (maximum value of y-axis set as 20 %)

One farmer declared that she had planted a pine forest where she used to grow coffee until the coffee wilt disease came and killed the plants. An additional farmer had cultivated a eucalyptus forest for ten years and was selling eucalyptus poles. One farmer stated that she grew napier grass and local grasses as fodder.

2. Animals

Forty-six per cent of the farmers kept one or more animals (Figure 18). Sixty-seven per cent of the respondents stated that they kept cattle, 51 % had pigs, 30 % kept goats, 28 % had chicken and one farmer mentioned sheep ()(Figure 19).

The average number of cows being kept by a farmer was two. Five farmers had one calf and one had several ones, two farmers kept a heifer. More than 20 % of the farmers mentioned that they kept their cows or heifers “zero-grazing” or “tethered”, only 5 % of the farmers mentioned that their cows were free-range. Seven per cent of the farmers mentioned that one or several cows had died from illnesses. One farmer explained that he had received a zero-grazing cow from “Send a Cow” and another one had received her heifer from “Send a Cow” as well.

The average number of pigs being kept was three. One farmer stated that he kept six piglets, another farmer only had one piglet.

The respondents kept four up to 20 chicken, the average was ten chicken. Sixteen per cent of the farmers explained that their chicken were local breeds, only one stated that he kept exotic chicken.

Most farmers kept between two and three goats. One farmer mentioned that he kept two kids and one farmer specified that he kept hybrid breeds. Another respondent mentioned that he received his goats from Heifer.

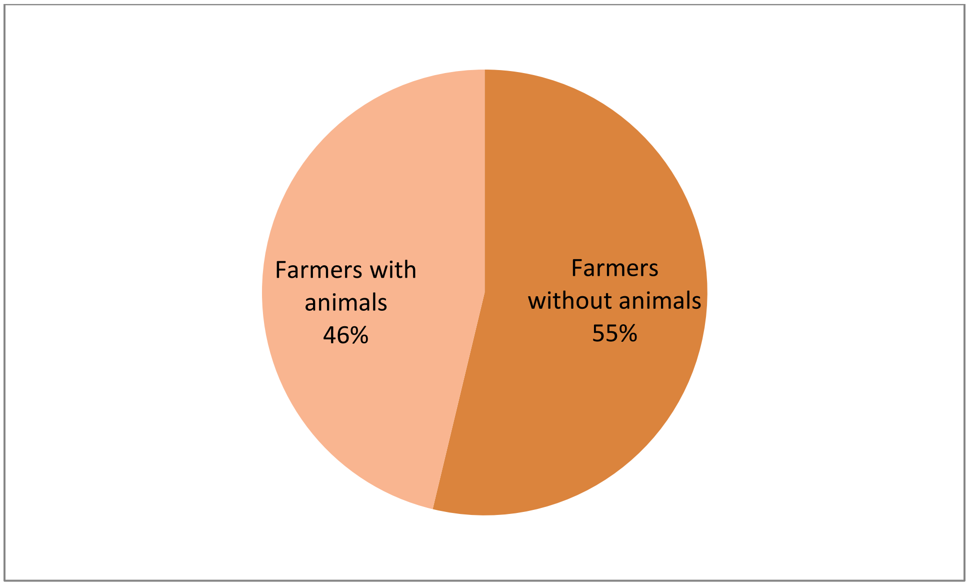

Figure 18: Percentages of interviewed farmers with (46 %) and without animals (55 %)

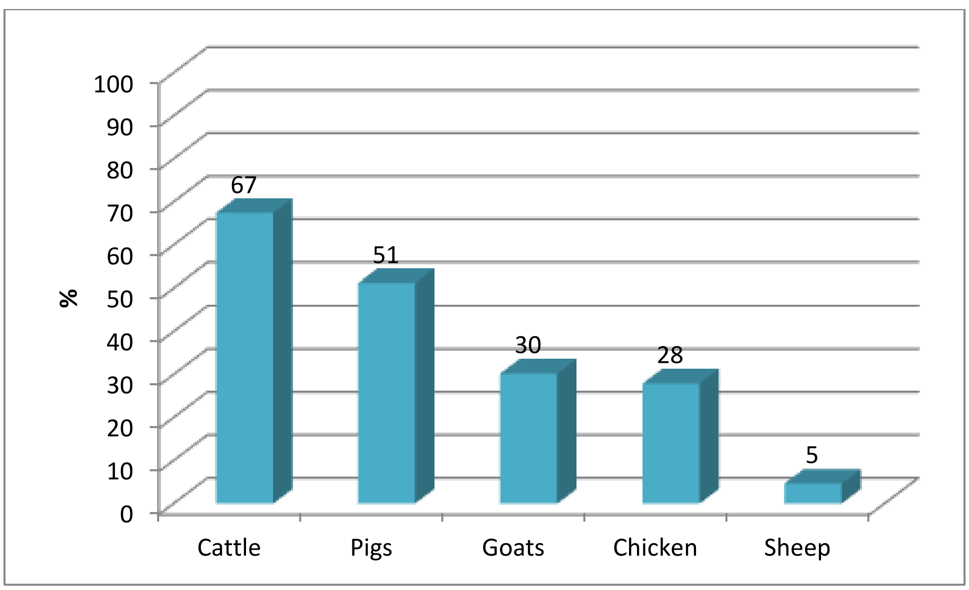

Figure 19: Percentages of farmers keeping different animals

3. Use of crops and animals

Most products such as plantain, beans, maize, vegetables and milk were used both for sale and for domestic consumption. Other uses were banana wine production or biogas from cow dung. Cow dung was also often used as fertiliser. One farmer in the first location stated that she was selling her coffee to the Ugandan coffee farmers organisation “NUCAFE” (National Union of Coffee Agribusinesses and Farm Enterprises). She was also selling her milk both to neighbors and to a cooperative. A farmer in the fourth location explained that he was selling his crops locally as there were no cooperatives. A farmer in the first location elaborated that he sells his products in a nearby town and his pigs only when he was in need of cash. Two farmers stated that they were selling their fruits, one of them to nearby schools.

6.1.1.4 Seasons

According to information from Mr Kefa Kalanzi and an informant at Villa Maria, the two crop seasons take place from the beginning of March until the end of May and from the middle of August until the end of November. January and February as well as the months June, July and August are dry periods. The rains usually start in early March and in the middle of August and last until the end of May and the end of December respectively, with the second period usually having the most rain. In 2013 the rains already ended before the end of May. While sowing takes place in February and March, April and May are months of weeding. At the end of May the coffee harvest can begin and from the middle of May until the middle of June beans and groundnuts are harvested. Maize is usually harvested from the middle of June until the middle of July.

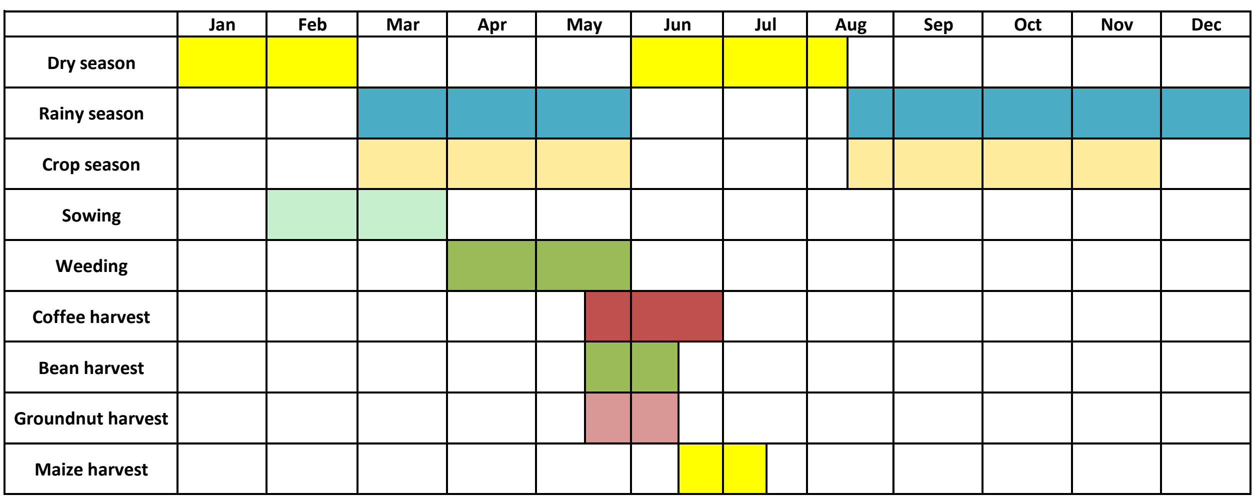

Figure 20: Seasonal calendar of Masaka region

6.1.2 General problems addressed by the farmers

Apart from pests and diseases and issues related to their treatment, the farmers shared other problems especially within the scope of the focus groups.

There were technical problems such as

- Weeds
- lack of labour
- expensive inputs such as artificial fertiliser and labour
- poor soil fertility due to poor management and over-use
- lack of storage facilities
- lack of fodder for animals
- lack of firewood in nearby surroundings
- climate change with unreliable rains and prolonged droughts
- lack of water harvesting facilities due to high material costs
- lack of irrigation facilities and
- lack of extension.

One farmer explained in detail that he had been struggling with the weed *Oxalis* spp. L.in his banana plantations for 20 years which was also disturbing his mulch and that no herbicide was efficient against it as it was dormant during the dry season with the help of its underground bulbs. Among five interviewees using herbicides, one of them explained that he was doing so due to the lack of labour. One interviewee explained that organic farming would be impossible if she did not have animals due to the poor soil fertility.

Furthermore, social problems were causing difficulties, such as

- animal thieves
- lack of collaboration between neighbours or group members and
- unstable prices due to the liberalisation of markets and lack of support from the government.

Two interviewees mentioned in particular that there were a few inactive farmers who were not adopting advice from groups and thus also discouraged others from participating. Two further respondents indicated that there was little cooperation between neighbours and that this situation led to the spread of diseases, as some pest management methods are only effective when implemented on a large scale and in collaboration between all farmers of an area.

6.1.3 Occurrence and management of pests and diseases

The pests and diseases affecting the main staple and cash crops are listed first and in descending order of their prevalence. Then, the pests and diseases affecting vegetables, including beans, cassava and groundnuts will be listed. Finally, storage pests and methods of their prevention will be elaborated. For the sake of completeness, animal diseases will addressed briefly as well. Tables 2-4 summarise the results for all plant pests and diseases at the end.

6.1.3.1 Coffee wilt

Coffee wilt was named as a problem by almost 70 % of the respondents in all locations. It was seen as the biggest and the major problem by two farmers in the first location and as a problem by all nine farmers in the third location. One of those farmers explained that the coffee wilt had been occurring for ten years and that it had been affecting the farm strongly. Also in the sixth location it was stated to have been occurring for eight years, while in the fifth one, it had only been occurring for one year. Another farmer in the third location mentioned that the wilt had been recurring even after replanting. A farmer in the first location stated that he did not have any problem with coffee wilt.

The main pest management method listed by the farmers was to cut and burn affected branches or to uproot and burn the whole plant. This method was stated by 40 % of the farmers. A farmer explained that he usually cut and burned affected branches in mornings and evenings and that this method was very effective, but also very tiresome and time-consuming. He voiced his frustration about inactive neighbours whose neglect of management kept spreading the disease to his farm. A farmer mentioned that although he was recommended to use this method by extension officers, the disease could not be controlled properly.

The farmer couple in the second location explained that extensionists had advised them to integrate cocoa in their coffee plantations so as to secure profits in the case of coffee wilt occurrence. Another farmer in the same location stated that the infection could be minimised through quick action, and that weeding in coffee plantations could prevent the spread of the disease. One interviewee in the third location explained that clean equipment could contribute to the disease prevention. She also mentioned that her grandparents used to create mulch from weeds and put it around the coffee stems so as to enhance soil fertility and thus the strength of the crop.

Five per cent of the farmers stated the use of pesticides. One had applied "Ducyper" in the past but changed towards the method of removing affected plants as the pesticide was not effective. Another farmer had been applying "Agrocid" twice a year for five years in addition to the herbicide "Weedmaster" in his coffee plantations.

6.1.3.2 Bacterial Banana Wilt

Banana wilt was listed as a problem in 65 % of the interviews in all locations. A farmer at the first location presented it as the second largest problem after coffee wilt. Another farmer in the same location explained that it was a big problem while he did not have any problems with coffee diseases. In the third location a farmer stated that the disease had been occurring for one to two years and was a major problem alongside coffee wilt. In the fourth location it was described as a minor problem by one farmer, in the fifth location a farmer stated that it had only been occurring for a month at the time of the interview. In the focus group in the latter location the disease was mentioned to have been highly affecting the banana production for two years. Also in the sixth location, it was revealed to have caused extensive damage to plantations. In the last location, a farmer explained that it had been affecting his farm for five years. In one location it was mentioned to occur in the dry season. Five per cent of the farmers explained that the infection could be minimised by quick action.

The main pest management method listed by the interviewed farmers was to uproot, cut and burn affected plants and replant new plants. This method was named by 30 % of the respondents. Five per cent of the respondents stated that they removed and burned exclusively affected parts of plants. Nineteen per cent of the farmers explained that they applied ash on the stock of removed plants or in the place where the plant was before being uprooted. One of those farmers also applied tobacco on the stock. It was mentioned four times that these methods were learnt from the parents or grandparents, though the disease was less prevalent in their times. Five per cent of the farmers named crop hygiene such the use of clean equipment as a management method for the banana wilt.

Some of the farmers used manure as a pest management method. A farmer stated that applying a mixture of cow dung and cattle urine around the stems of his plants proved very effective. Another farmer explained that pig dung was generally more effective than cow dung. A farmer in the third location explained that her grandparents used to collect mulch after weeding and to apply it around the stems. A farmer interviewed in the fourth location mentioned that his parents had used coffee husks as fertiliser.

One of the farmers stated that she extracted solutions from different pesticidal plants such as *Tephrosia vogelii* (Hook. F.), Mexican Marigold (*Tagetes minuta*), *Phytolacca dodecandra* L'Hér., Chili pepper (*Capsicum frutescens),* woodash and animal urine and created different combinations of them to treat banana plants or vegetables.

Five per cent of the farmers applied pesticides against banana wilt. One had applied “Ambush” and “Rocket” for a short time and “Furadan” every three months. He explained that he found “Rocket” to be most effective. Another farmer stated the he had used “Furadan” since he started farming.

Five per cent of the farmers stated that they had no knowledge about the management of banana wilt.

6.1.3.3 Banana Weevil

Banana weevils were named as a problem by 60 % of the respondents in all locations. In one location they were claimed to have been occurring for more than ten years, on another farm in the same area (Kiteredde parish) they had only been occurring for one year. This pest was mentioned as the major problem several times in Bugubira sub-parish. Here, another farmer stated that although banana weevils had been observed in the area for a long time, their contribution to yields decline had become a serious problem only recently.

In 40 % of the interviews where the banana weevil was mentioned as a problem, the pest management method named was the application of woodash around the stem, which is effective against the pest due to its acidity. Usually the woodash was applied after removing weeds and uprooting dead stems in every season, which was also described as “dissuckering”. This practice as a general farm hygiene practice can by itself be seen as one of the methods of management of the banana weevil. In one location, it was stated that the application of woodash is especially effective in the rainy season. Thirty-three per cent of the farmers who applied woodash mixed it with cow urine. In one location, a concoction of woodash, cow urine and *phytolacca* (*Phytolacca* spp. L.) was applied, which was locally named as "mamadika fiutida". Another farmer explained that she applied a liquid mixture of woodash and animal urine three times per week in the dry season by irrigating it around crops. One farmer applied a mixture of woodash, animal urine and pepper (*Piper nigrum*) and another interviewee described the use of a mixture of cow urine, chilli (*Capsicum frutescens)*, woodash and *Aspilia africana* L. M. A. A. Du Petit-Thouars (locally known as “Makaayi”) either undiluted two weeks after preparation or directly applied after diluting it with water in a ratio of 1:2. The use of woodash as pest management was described as a method adopted from the parents or ancestors in five locations. In one location, it was explained that there were not as many pests prevalent in their parents' time as today and thus woodash was the only pest management method used. In another location, instead of woodash, the ash of the weed *Commelina benghalensis* L. was applied to the crop after burning the leaves. Woodash was also named as a pest management method of black ants, cutworms and aphids on vegetables, banana wilt, coffee wilt and maize stalk-borer. Furthermore, it was used for grain and bean storage in two locations.

In one location, a mixture of tobacco (*Nicotiana tabacum* L.), *phytolacca* and chilli was applied twice a year after the start of the rains respectively. Another farm applied liquid manure made from plants such as *phytolacca* which was stored for seven days before application. Such a mixture is described as "plant tea" by educational staff of NGOs and will be further described in paragraph 6.2.2. Only one farmer mentioned the removal of weevils by hand-picking and subsequent burning as a method. Similarly, a method of trapping was named only once. In this case, the stem was cut into two pieces and the weevils which had been attracted to the stems were crushed after trapping.

Sixteen per cent of the interviewed farmers stated that they used chemical pesticides to control the banana weevil. In one case, it was the pesticide "Rocket", in three cases it was "Furadan", and in three more cases the name was not known or mentioned. One of the farmers explained that he had been given a chemical from NAADS whose name he did not know. The farmer who applied "Rocket" stated that he used the chemical according to the instructions on the container. One of the interviewees explained that her husband had bought a pesticide four years ago whose name she could not state. One of the farmers applying "Furadan" added that he had been using this chemical for six months, i.e. at the beginning of the rain seasons. A farmer claimed that he had no knowledge about how to manage the banana weevil, but he would like to have financial support to buy artificial pesticides.

6.1.3.4 Coffee weevil (Black twig borer)

The coffee weevil was named as a problem by 33 % of the farmers. Especially in the fourth location it was listed by all coffee growing farmers apart from one, and in the focus group discussion in the fifth location it was mentioned that the pest had "highly invaded" the plantations. Five per cent of the farmers stated that it had been a problem for three years and one for two years.

The only management method listed by farmers was, similarly to coffee wilt, to cut off affected branches or uproot and burn affected plants. This method was stated by 19 % of the interviewees and one farmer in a focus group. A respondent explained that he was continuously removing affected branches but it did not help to improve the situation. He mentioned that his parents had not had this problem. Five per cent of the farmers stated that they had been recommended this method, one of them by extensionists from the agricultural department. One farmer was using the chemical "Agrocid" in her coffee plantations both against coffee wilt and the coffee weevil and applying the herbicide "Weedmaster" to increase the resistance of her crops.

6.1.3.5 Maize stalk-borer

The maize stalk-borer was listed as a disease by 35 % of the interviewees. It was stated to be a major problem in the second and fourth location and to occur every year in the third location.

The main management method for the maize stalk-borer was the application of pesticides. Forty-four per cent of the farmers stated that they applied chemical pesticides in their maize fields, 30 % of them were using “Ambush”. Two farmers mentioned the use of “Ducyper” and the remaining farmers did not know or mention the name of the chemical. One farmer had started using chemical pesticides only in the current season; two farmers had been using “Ambush” for two years, one farmer for three years, two farmers for four years and one farmer for ten years. One of the respondents stated that she had been using Ambush every season and thus twice a year, another farmer mentioned that he was not using “Ambush” frequently and another respondent said that she was using the chemical only when the pest was occurring, which would usually not happen in the case of intensive rains. Two farmers explained that they were diluting 3 ml and 5 ml in 20 litres of water respectively, one interviewee stated that in the case of the application of wrong quantities the maize could get burnt. One farmer explained that he would like to use organic pesticides but they were too expensive. Two farmers were using herbicides in their maize fields.

Five per cent of the farmers explained that they used to apply woodash, but have changed to chemicals or were now additionally using pesticides. One of them used to put woodash into the primary leaves of the maize and stated she had been recommended this method by DATIC (District Agricultural Training Information Centre). Another farmer was still applying woodash mixed with water and applied as a spray. One farmer stated that storing his seeds for three seasons made the maize less prone to the pest.

Improving the nutritional status of the crop was also used as a method to increase its resistance against the pest. Nine per cent of the respondents stated the use of organic manure and 7 % were using chemical fertilisers such as “Digrow”, “DAP” and “NPK” or “plant boosters”. One of the farmers who applied organic manure was using cow dung, cow urine and mulch. Another farmer mentioned that she found pig dung more effective than cow dung and that it was increasing the yields and green colour of her maize plants. Another respondent stated that he had found a mixture of poultry manure and cow dung most effective to increase maize yields. Chicken manure was also described as yield improving by another interviewee.

In one of the focus groups, the farmers described that their ancestors used to tie steamed banana leaves to their maize plants to prevent the maize stalk-borer. They also stated that their parents used to put soil into the primary fan of the maize plants during weeding for the same purpose.

6.1.3.6 Vegetable and fruit pests and diseases

Forty-seven per cent of the farmers listed problems with vegetable pests and diseases, 7 % did so within focus groups. Twenty-eight per cent of the respondents named aphids as a problem, which mostly affected beans, but also cabbage and other vegetables. Cutworms or caterpillars were named as a problem by 16 % of the farmers. They were said to affect cabbage, sweet potatoes and African eggplants. Fourteen per cent of the interviewees listed cassava diseases, 9 % specifically the African Cassava Mosaic Disease (ACMD). Twelve per cent of the farmers named bean infections, one of them stated that they occurred when the beans were planted in the rainy season. Seven per cent of the respondents described that their beans had infections which turned their leaves yellow; one of them said that this usually happens after sowing. One farmer brought up the problem of bacterial stem wilt of beans in a focus group, which had been occurring since long and was destroying the plants before flowering. Five per cent of the farmers were having problems with the “groundnut curling” disease, supposedly caused by thrips. One farmer listed problems with black ants and one with tomato wilt. The farmers specialized in Irish potato and onions were having problems with Irish potato blight and onion blight. Five per cent of the respondents listed problems with soil fertility; the first one with regard to sweet potato and the second one with regard to beans. Figure 21 gives a graphical overview of the vegetable pests and diseases listed.

Sixteen per cent of the farmers stated to have problems with fruit pests and diseases including fruit flies, mealybugs, bacterial wilt and fungal diseases or moulding. Fruit flies, which were mentioned as a problem by seven farmers, mostly affected mangos and avocados, but also green peppers in a case. The yields of a farmer were reduced by up to 75 % by the flies. Another respondent explained that his avocados were usually affected in the flowering stage in both seasons. Mealybugs affected the orange production of a grower. In a focus group, it was stated that passion fruits had been affected by bacterial wilt and fungal diseases which caused yellow leaves and rotten roots.

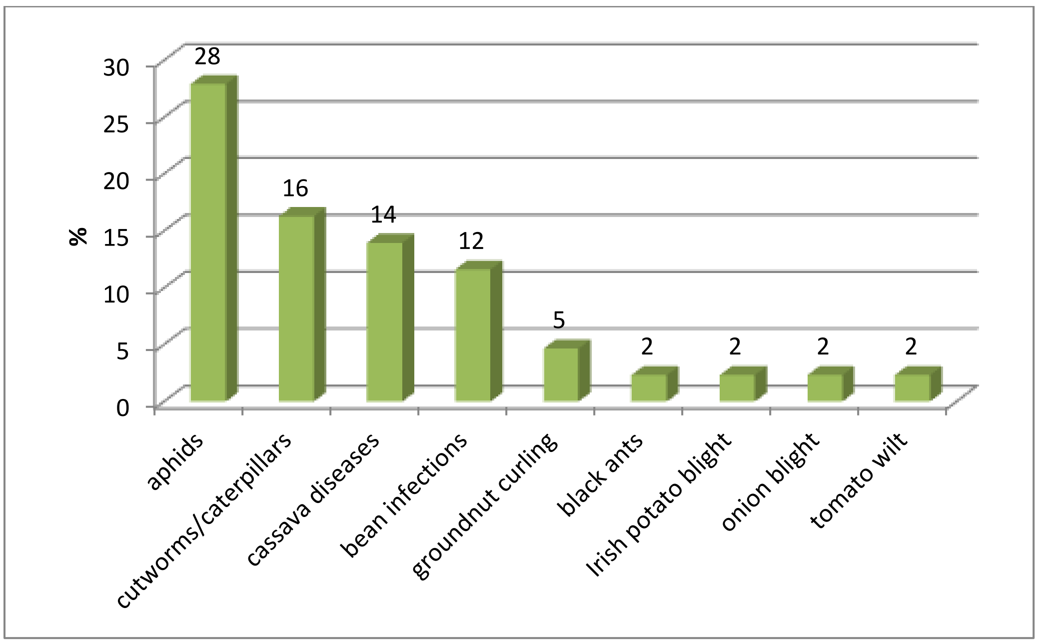

Figure 21: Vegetable pests and diseases listed by farmers (maximum value of y-axis set as 30 %)

Sixteen per cent of the interviewees were using pesticides and 30 % of the farmers listed traditional methods of pest management for their vegetables and fruits. Five per cent of the respondents stated that chemical pesticides were effective for treating their crops; another 5 % of the interviewees had found chemicals not to be helpful. One farmer explained that spraying Ambush had affected her bananas so that she had stopped using it. Another farmer stated that she did not want to use chemicals and at the same time did not have knowledge about organic methods apart from the method of clearing the bush from weeds through burning, which she had learnt from her parents. One respondent did not use chemicals on his mangos as the trees were too high for that and another farmer stated the same about his avocados. Five per cent of the farmers were using chemicals for their beans to prevent diseases. Twelve per cent of the interviewees were applying diluted “Ambush”, against caterpillars on sweet potatoes, aphids on beans, caterpillars or other pests on vegetables (two growers) and to treat Irish potato blight and onion blight twice a year. Another chemical named was the fungicide “Dithane M45” and two farmers were applying “Digrow” as /a fertiliser.

Applied mixtures listed as traditional methods to manage aphids were *jatropha* (*Jatropha* spp L.) sap and water; *Tephrosia vogelii*, Mexican marigold (*Tagetes minuta*), *phytolacca*, chilli (*Capsicum frutescens)*, woodash and animal urine; and diluted animal urine, chilli and woodash. Furthermore, chilli and *phytolacca* were applied whenever pests were sighted and on cabbage before it makes its head. The application of soap and *tithonia* (*Tithonia* spp. Desf. Ex Juss.) or woodash, a concoction of animal urine and woodash and *phytolacca* were further methods listed. Another method stated was planting the pencil tree (*Euphorbia tirucalli*) as a repellent and furthermore applying “plant tea” as described in 6.2.2 was listed.

Besides using the same methods reported for aphids, cutworms and caterpillars were additionally treated with coriander as a repellent. A farmer described that she applied a mixture of animal urine and chilli since she had received a heifer from “Send a cow” 1,5 years before the interview. Earlier her only method had been to clear weeds before planting.

To control the Cassava Mosaic Disease (ACMD), 5 % of the farmers named the method of uprooting, burning and replacing affected plants and one interviewee stated the she was using healthy planting material. One farmer in a focus group said that he was lacking technical advice on how to manage the disease.

A respondent who had problems with bean infections explained that he was uprooting affected plants and leaving them to die and that he did not know any other solution till now. The farmer whose beans were affected by bacterial stem wilt did not know any management method.

A farmer who reported problems with the groundnut curling disease was using the same method as for other vegetable diseases, i.e. applying a mixture of *Tephrosia vogelii*, Mexican marigold (*Tagetes minuta*), *phytolacca*, chilli, woodash and animal urine. The other farmer with the same problem did not know of any management method.

The farmer whose vegetables were affected by black ants stated that she applied a mixture of Mexican marigold (*Tagetes minuta*), wood ash and white soap. To prevent the Irish potato blight and onion blight, the affected farmer used chemical pesticides, stating that he was spraying them only on the mature crops in case he had planted them early, and more frequently when he had planted them late, as the blight was occurring more often in that case. The farmer whose tomatoes were affected by wilt did not name any management method.

Five per cent of the farmers whose mangos and avocados were affected by fruit flies stated that their trees were too high to treat the crop. One of them also said that she did not have any knowledge about how to treat her avocados, and the same was stated by another respondent with regard to his mangos and avocados. The farmers who reported problems with their passion fruits in a focus group similarly explained that they were lacking knowledge about management methods and that chemical pesticides had not been effective. They also said that this crop had been a new enterprise for five years, but that extensionists were having no training about their management, as it was not a high value crop. The farmer whose oranges were attacked by mealy bugs was using the same method as for bananas and vegetables, i.e. applying a mixture of animal urine, woodash and *phytolacca*. No management method was mentioned for fruit moulding.

6.1.3.7 Storage pests

Almost 90 % of the interviewees stated that they were using methods to avoid storage pests. Furthermore, different methods were listed in two focus groups. A third of the respondents were using these methods for maize, two thirds of them for beans and one respondent for onions. 30 % of the farmers did not mention a specific crop but it can be assumed that they were also treating their maize and/or beans. Sixteen per cent of the respondents were using chemicals, one of them “2 % Malathion Dust”.

The most frequently listed natural method for storing was drying the grains in sunshine. This method was listed by 50 % of the farmers, 23 % of them for beans and 14 % for maize specifically. The second most common method was mixing cypress leaves with the grains (presumably *Cupressus lusitanica* or *Cupressus sempervirens* (Mwine *et al.*, 2010)). Additionally, 14 % of the farmers were using a mixture of cypress leaves and chilli (*Capsicum frutescens)* and one stated the use of a mixture of cypress leaves and pepper (*Piper nigrum* L.). Nine per cent of the farmers were using chilli alone and 5 % applied a mixture of chilli and woodash. Twelve per cent of the farmers were using woodash alone. The third most common method was to not store the grains for a long time. In this way, the products were either sold or consumed domestically directly after the harvest. This method was listed by 16 % of the farmers, 14 % of them for maize and one for beans, and 5 % of them were consuming their maize domestically while one of them was selling the maize after harvest. Nine per cent of the farmers used marigold (*Tagetes minuta*), one of them explained in detail that she crushed the leaves when they were still fresh and then dried them with her beans which could then be stored for three months until the next planting. She was using two handfuls of fresh marigold leaves for 20 kg of beans. Five per cent of the respondents stated that they stored their maize with its husks and one explained that she did not remove the maize grains from the cobs until she would process or sell them. Five per cent of the farmers stored their grains in sacks; one of them in combination with chilli and one elevated the sacks on platforms. Another five per cent of the interviewees stored their maize or beans on the cool floor after drying where there was good air circulation. A farmer mixed her grains with local herbs from her garden and leaves from deciduous trees, another one mixed pounded indigenous onion with her grain. A farmer dried fresh tobacco leaves with the beans and someone else applied banana juice. A mixture of anthill soil, chilli and pellets was also used, which made it possible to store the maize and bean seeds for the next season. The farmers who were specialised in onions explained that they dried their crop and hung them up in bundles, which made it possible for them to be stored for a long time.

6.1.3.8 Animal diseases

A farmer explained that his cattle had worms and his pigs would also get diseases when he did not spray them with alcalicides. He said that he had to use expensive ones as the cheap ones were not effective. Another farmer stated that her chicken had problems with chicken flu and one respondent was vaccinating her chicken which prevented diseases. One farmer mentioned that his animals were having diseases and another one that his cows were having various diseases. Five per cent of the farmers were having problems with chicken coccidiosis and treating them with *aloe vera*. One of them was having problems with her cows suffering from tick borne diseases. She used alcalicides and also garlic (*Allium sativum*) and *eucalyptus* leaves for deworming any animal identified as sick and stated that she could not afford chemicals for deworming, but her natural methods were effective. Five per cent of the farmers explained that their animals were treated by veterinary doctors and one farmer explained that he used artificial insemination which was very costly and not very effective.

Table 2: Summary of the results concerning management methods of pests and diseases (part 01)

Disease/Pest	Coffee wilt	Bacterial Banana Wilt
Percentage of affected respondents	70%	65%
Percentage of farmers using pesticides	5%	5%
Traditional management methods	cut & burn affected branches, uproot & burn affected plant (40%)	uproot, cut & burn affected plants, replant new plants (30%)
	grow cocoa as an alternative crop	apply ash on stock of removed plants (19%)
	weeding	cut & burn affected parts of plants (5%)
	clean equipment	crop hygiene & clean equipment
	mulch to improve soil fertility	apply ash & tobaccon on root stock
		manure (cow dung, cattle urine, pig dung, mulch, coffee husks)
		pesticidal plants (tephrosia, marigold, phyto-lacca, chili) with woodash & animal urine

Table 3: Summary of the results concerning management methods of pests and diseases (part 02, descriptions of rows as in Table 2)

Banana weevil	Coffee weevil (Black twig borer)	Maize stalk-borer
60%	35%	35%
16%	(5%)	44%
Woodash (40%)	cut off affected branches, uproot & burn affected plants (19%)	woodash mixed with water & applied as spray
Woodash & cow urine		store seeds for three seasons
woodash, cow urine and phytolacca		organic manure (cow dung, cow urine, mulch, pig dung, poultry manure)
woodash, animal urine and pepper		steamed banana leaves
cow urine, chilli, woodash and Aspilia africana		soil in primary fan of plants
ash of Commelina benghalensis		
tobacco, phytolacca and chilli		
"plant tea"		
hand-picking and burning of weevils		
trapping		

Table 4: Summary of the results concerning management methods of pests and diseases (part 03, descriptions of rows as in Table 2)

Vegetable & fruit pests and diseases	Storage pests
47% & 16%	90%
16%	16%
jatropha sap and water	drying in sunshine (50%)
Tephrosia vogelii, Mexican marigold, phytolacca, chilli, woodash and animal urine	cypress leaves
diluted animal urine, chilli and woodash	cypress leaves & chilli
chilli and phytolacca	cypress leaves & pepper
soap and tithonia or woodash	chilli
concoction of animal urine, woodash and phytolacca	chilli & woodash
planting the pencil tree	direct consumption/sale
"plant tea"	marigold leaves
coriander (cutworms/caterpillars)	store maize with husks
animal urine & chilli (cutworms/caterpillars)	storage in sacks and with chilli / on platforms
clear weeds before planting (cutworms/caterpillars)	storage on cool floor
uprooting, burning & replacing affected plants (Cassava Moisaic Virus)	local herbs & leaves from deciduous trees
healthy planting material (Cassava Mosaic Virus)	pounded indigenous onion
uprooting affected plants (bean infections)	fresh tobacco leaves
mixture of Mexican marigold, wood ash and white soap (black ants)	banana juice
	mixture of anthill soil, chilli and pellets
	hang up in bundles (onions)

6.1.4 Effectiveness of management methods

A bit over 20 % of the respondents stated that their methods were very effective. Fourteen per cent of them were using traditional methods; 5 % were using chemical pesticides and one respondent made this statement about the fertiliser “Digrow”. One of the respondents mentioned that although cutting and burning diseased branches was very effective to control coffee wilt, it was also very tiresome and time-consuming. One farmer was applying cattle urine and cow dung around his banana stems to manage banana wilt, while another one was using woodash and tobacco against banana wilt and a third respondent applied burnt *Commelina benghalensis* against the banana weevil. A respondent who tried to prevent coffee wilt and banana wilt stated that the positive effects of crop hygiene were already visible after eight months of practice. Another interviewee said that chicken manure was very effective to increase her maize yields. The farmers who found chemicals very effective applied them against the maize stalk-borer or used “Rocket” against banana wilt.

Almost 60 % of the interviewees responded that their methods were widely or partly effective. Fifty per cent of them were using traditional methods and 28 % were using chemical pesticides. One respondent explained that the effectiveness of both traditional and chemical methods was dependent on the interest with which the farmer pursued these methods. Nine per cent of the farmers stated that removing affected plants was effective to control coffee wilt, 14 % controlled banana wilt successfully through removing affected fruits, uprooting affected plants, cutting the stem continuously, applying woodash or woodash and animal urine, applying animal urine and cowdung around the stem and applying plant tea. Nine per cent were managing the banana weevil by applying woodash or a mixture of woodash, animal urine and pepper (*Piper nigrum*). Five per cent of the farmers stated that poultry manure was increasing their maize yields and one farmer mentioned that pig manure was more effective than cow dung. Seven per cent of the respondents were satisfied using traditional methods for their vegetables such as a mixture of animal urine, woodash and *phytolacca*, a mixture of animal urine and chilli (*Capsicum frutescens)* and a combination of *Tephrosia vogelii*, Mexican Marigold (*Tagetes minuta*), *Phytolacca dodecandra*, chilli (*Capsicum frutescens),* woodash and animal urine. The farmer using the last concoction stated that the preparation was time-consuming, but the method was effective when used continuously. Twelve per cent of the respondents found their methods for storage effective, including mixing beans with cypress leaves alone or in combination with pepper or chilli, storing maize with its husks, applying woodash or woodash and chilli on maize and drying maize and beans continuously. One of those farmers stated that cypress and chilli was more effective than chemical pesticides. One farmer was effectively using garlic (*Allium sativum*) and *eucalyptus* for deworming her animals. The farmers who used chemicals applied them against the maize stalk-borer, vegetable pests, the banana weevil and banana wilt. One farmer explained that only chemicals helped against the maize stalk-borer and traditional methods were ineffective. Another of the respondents mentioned that the chemical “Rocket” was especially effective against the banana weevil when applied during the dry season. One farmer was using “Furadan” against banana weevils and one used “Ambush” for maize and another one “Ambush” and “Ducyper” for maize. One farmer was using alcalicides to treat his animals and explained that only the expensive ones were effective.

Nine per cent of the farmers stated that traditional methods were not effective and four did not find chemical pesticides effective. The farmers who found traditional methods ineffective had tried cutting affected branches to mitigate coffee wilt, uprooting and removing plants affected by coffee wilt or banana wilt and applying woodash and animal urine against the coffee and banana weevil. One respondent stated that the effectiveness of her methods was dependent on her activeness. One farmer mentiond that traditional methods had not been effective to control the maize stalk-borer. One of the farmers who did not find chemicals effective explained that there was the problem of duplications on the market. Another respondent had been applying “Ambush” and “maize booster” for four years and stated that the pests were increasing and he needed technical advice for other methods. One farmer explained that “Ducyper” was ineffective against coffee wilt and farmers in a focus group stated that chemical pesticides had not been helping against passion fruit diseases.

6.1.5 Opinions on Chemical pesticides

Sixty-five per cent of the respondents were using chemical pesticides, 44 % of them against the maize stalk-borer, 16 % against the banana weevil, 16 % against storage pests, 5 % against banana wilt, coffee wilt, bean diseases and other vegetable diseases respectively and one against the coffee weevil, caterpillars on sweet potatoes, Irish potato blight and onion blight respectively. The most common pesticide was “Ambush”, which was used by 28 % of the farmers against vegetable pests, the maize stalk-borer and banana wilt. Furthermore, “Furadan” was used by 9 % of the farmers against the banana weevil and banana wilt, “Rocket” was used by 5 % of the farmers against the banana weevil and banana wilt by two farmers, “Ducyper” was used by one farmer against the maize stalk-borer and had been unsuccessfully used by another respondent against coffee wilt, and “Agrocid” was used by one respondent against coffee wilt. Nineteen per cent of the farmers said that they were using herbicides and two mentioned the use of alcalicides to treat their animals.

More than 60 % of the interviewees had awareness about harmful effects of chemical pesticides. Fifty-three per cent of them referred to their danger to human health, 9 % explained that they affected the plants, 7 % mentioned the impact on the environment and 7 % the impact on soil fertility. Nine per cent of the farmers explained that they were not aware of any effects.

Fourteen per cent of the farmers stated that they knew about the effects from trainings from NGOs such as “Send a Cow” and a health organization and trainings from the government. Five per cent of the interviewees explained that NAADS extensionists were promoting the use of chemical pesticides and 7 % had learnt how to use pesticides from NAADS trainings. One interviewee stated that generally, more NGOs were training farmers to adopt organic methods rather than conventional ones. One respondent explained that he knew about the use of pesticides from farm shops, another interviewee used them according to the instructions on the container and one farmer mentioned that the use had been demonstrated in trainings. One respondent mentioned that he was aware of the risks of chemicals through radio programmes. Another respondent stated that she had ceased using Malathion for storage for a few seasons due to what she had learnt in the trainings and that she now was using natural methods instead. One interviewee said that she did not use chemicals for storage even though other farmers said they were effective.

The farmers who reported knowledge about the impact of chemicals on human health frequently mentioned that they were taking precautions such as washing their food before cooking it, keeping their children away from the chemicals and using protective measures while spraying such as protection masks. One respondent stated that she sometimes had headache after spraying, another farmer explained that she had stopped using chemicals as her family had got stomach pain from eating the treated grains and another respondent also mentioned that she did not want to use chemicals for crops which were used for her own family's food. One interviewee stated that she had heard from other people that chemicals would cause health problems, but she hadn´t noticed it herself. One farmer was aware that the use of chemicals could cause illnesses in future and another respondent explained that they may cause cancer.

Five per cent of the farmers who reported effects on the plants stated that wrong quantities of chemicals could burn the maize leaves and one of them added that excessive use of plant booster would lead to curled maize leaves. One of the farmers who were aware of the impact on soil fertility related this problem to decreased yields. Another respondent stated that organic farming would not be possible without animals due to the loss of soil fertility. In one of the focus groups, a farmer explained that her bananas died away after the application of chemical pesticides and that she preferred natural methods. Furthermore, her chicken had died from eating weevils, which had consumed the pesticide.

Seven per cent of the farmers stated that they found indigenous methods more effective than chemicals. One respondent said that he had been using chemicals against the maize stalk-borer but that pests were increasing and he needed technical advice for other methods. In one of the focus groups, the farmers explained that the pests had become resistant to the chemicals and that new pests and diseases had been introduced. In another focus group, it was mentioned that natural methods were more effective for storage than chemical ones. One farmer stated that the performance of pesticides could be improved through more labour and another respondent explained that the effectiveness of both chemical and organic methods was dependent on the interest and effort put into them. One interviewee stated that chemical pesticides were more effective against the maize stalk-borer than traditional methods. One respondent said that she was not very aware of organic methods and another farmer said that he would like to use chemicals if he had enough money to buy them.

6.1.6 Access of farmers to knowledge and indigenous knowledge

Figure 22 gives an overview of the sources of knowledge listed by the respondents.

Fifty-six per cent of the interviewees stated that they had their knowledge about pest management from NAADS trainings and extensionist visits. The trainings offered by NAADS were stated to usually take place at the respective sub-county headquarters. It was explained by one respondent that the frequency of trainings depended on the governmental programme schedules. One farmer mentioned that they take place four times a month, in a another location it was monthly, one interviewee stated that they took place four times a year and one respondent explained that they were taking place once in five to six months. The content of the trainings was described as the proper use of pesticides, hybrid crops, livestock management, methods to achieve high maize and coffee yields and methods to benefit from a small piece of land through fertiliser and intercropping. Twenty-three per cent of the farmers stated that there were no trainings offered by NAADS or that they did not participate in them. One respondent explained that the trainings were not efficiently communicated and he gets to know about them when they have already happened.

Fifty-one per cent of the respondents named their parents as a source of knowledge. Five per cent of the farmers stated that this knowledge only referred to general farm management, Forty-seven per cent explained that they had learnt pest management methods from them. It was mentioned several times that the parents did not have as many problems with pests and diseases and that they also did not use chemicals or artificial fertilisers, but only natural methods such as farm hygiene, bush clearing through burning, uprooting affected plants, trapping and dissuckering against banana weevils, woodash against banana wilt, banana leaves and the application of soil in maize fans against the maize stalk-borer and grain storage with ash, Mexican Marigold (*Tagetes minuta*), juice from local bananas or cypress leaves. Mr Kalanzi explained that a major problem contributing to this situation is the fact that new pests and diseases have been introduced to Uganda and the Masaka region which the farmer generation of today has no traditional knowledge how to tackle since their parents did not face these problems. Bacterial wilts came to the region five years ago and have become an increasing problem since no appropriate measures have been taken against them. In addition to that, the seasons have become very unbalanced in the last 15 years and at the same time, the government has been transforming wetlands and forests into industry which has even aggravated climate related problems. Thus, the environment has changed that much that parts of traditional knowledge from ancestors have become irrelevant for today's farmers. Lastly, land fragmentation with concurrent population growth has been a problem, for example farms used to be up to 50 acres in the past, while today most of them comprise less than 2 acres, and the population has grown from 12 Mio in 1972 to 35 Mio today. This development was causing urban migration and thus reducing the number of young people in rural areas, who could learn and pass on traditional knowledge.

One farmer explained that his parents had only kept local animal breeds, which were very resistant to pests and diseases. One interviewee stated that his parents had used compost manure, two farmers named mulching as a method used by their parents and another's farmer's parents had been applying coffee husks as fertiliser.

Thirty-five per cent of the farmers stated that they had retrieved their knowledge from trainings offered by NGOs. The NGOs named were Send a Cow (26 %), MADDO (14 %), World Vision (7 %), Heifer / EADD (East African Dairy Development Project) (5 %), Vi Agroforestry (5 %), US Aid (2 %) and UNFFE (2 %) (see also Figure 23). Trainings by Send a Cow were stated to take place once a week, twice a week for one month and every two months by different farmers. The NGO was said to donate cows in order to improve the nutrition of children and to contribute to the income of farmers and to teach about organic agriculture and pest control methods. MADDO was explained to have been offering trainings once in one to two months for four years by one respondent and to teach about plant hygiene, natural pesticides and storage methods of beans by three different respondents. World Vision was said to offer trainings once in three months by one farmer and to teach about child welfare, savings groups and women's awareness of health at the domestic level by two further respondents. One of those respondents stated that the trainings by World Vision were the best ones she had received so far. Heifer was mentioned to offer trainings to farmers through their East African Dairy Development Project and Vi Agroforestry was described to teach about the use of local medicines and herbicides. UNFFE was mentioned by one farmer besides Send a Cow who described that their trainings took part twice a week at the sub-county headquarters for one month and they taught about different farming methods based on natural systems, fish farming and animal production and management. Sixteen per cent of the farmers stated that there were no trainings offered by NGOs in their region. One respondent explained that some farmers were very inactive and did not make use of the trainings and another interviewee mentioned the same as a reason for his own discouragement to participate in groups.

Thirty per cent of the farmers listed farmers groups as a source of their knowledge. They were stated to meet every week by one respondent, twice a month by 9 % of the farmers, once a month by 5 % of the farmers and once in three months by one farmer. They were furthermore described to have been existing or attended for ten years by 7 % of the farmers, four years by 5 % of the farmers and seven years, five and a half years, five years, three years and two years by one respondent respectively. The group size ranged from fourteen to 30 members. Fourteen per cent of the interviewees stated that they shared their own knowledge within the groups. Nine per cent of the farmers stated that they did not take part in any groups. In Kasana parish, one interviewee explained the set-up of the saving group in the same location. She explained that the group had existed for one year and consisted of 50 members. They had been a "Send a Cow" group before and the woman representative of the district council had introduced the saving group concept to them. Each member has to buy five shares of 5000 UGX (13 SEK) and to pay 200 UGX (0,50 SEK) in every meeting. The interest rate for loans is 1500 UGX (3,90 SEK) per 10.000 UGX (26 SEK) and the maximum time frame to pay back the money is three months. Money is usually borrowed for personal development projects, school fees for children or hospital visits. Fourteen per cent of the interviewees stated that they did not participate in any farmers groups.

Nineteen per cent of the farmers stated that they retrieved their knowledge from fellow farmers or neighbours. One respondent mentioned that she knew from neighbour farms where to get clean plant material, another farmer retrieved knowledge about the management of banana wilt and coffee wilt from his neighbours. Five per cent of the interviewees knew about storage methods and one about the use of "Ambush" from fellow farmers.

Nine per cent of the respondents named their grandparents, 9 % their friends, 7 % their sisters and 7 % their ancestors as a source of knowledge. One respondent knew about the use of pesticides from farm shops and one used them according to the instructions on the container. One respondent stated that he had awareness about the risks of chemicals from radio programmes. Similarly to the parents, it was mentioned that the ancestors and grandparents had not been facing the same problems as today and that they only used traditional methods such as woodash and mulching. One respondent explained that their ancestors used to tie steamed banana leaves to maize plants against the maize stalk-borer. One farmer knew about traditional methods from a friend, one about the use of “Ambush” and one was taken to trainings by a friend. The husband of the family who was specialised in potatoes and onions had been visiting a friend who was also growing onions to get advice.

Twenty-three per cent of the farmers stated that they shared their own knowledge, 14 % of them within farmers groups and 7 % with fellow farmers or neighbours.

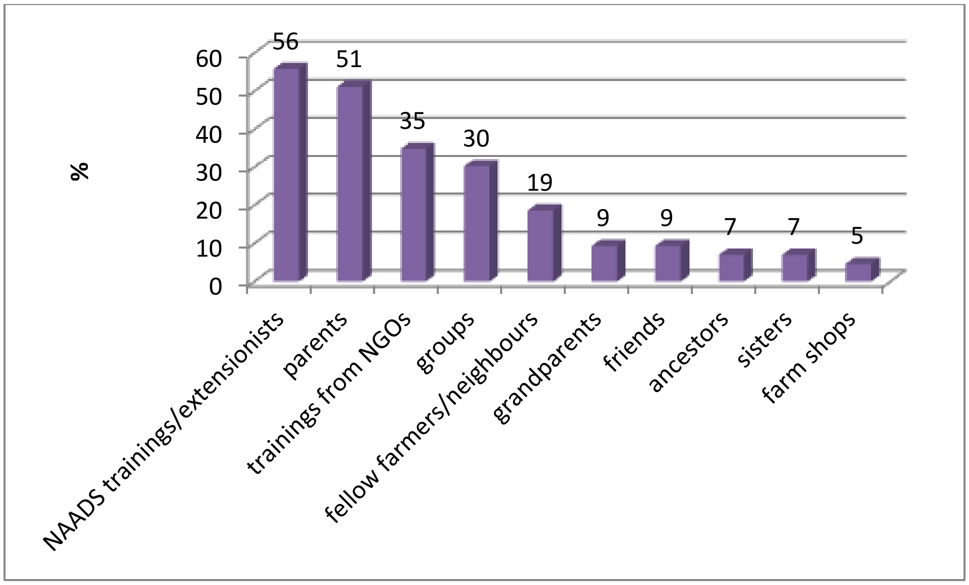

Figure 22: Sources of knowledge listed by farmers (maximum value of y-axis set as 60 %)

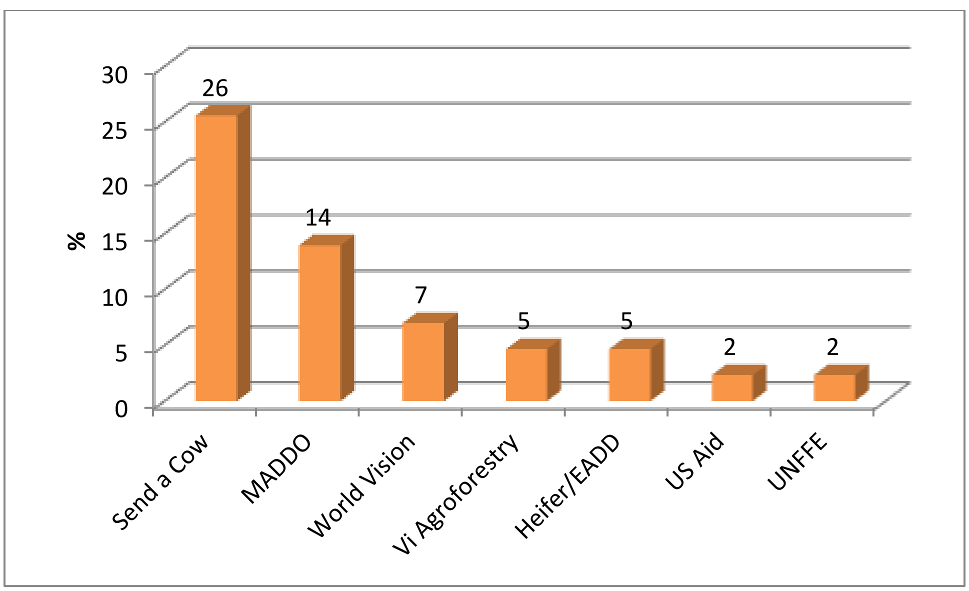

Figure 23: NGOs offering trainings listed by farmers (maximum value of y-axis set as 30 %)

6.1.7 Possible improvements of farmers' knowledge

Figure 24 depicts the proposed sources of knowledge listed by the respondents. Forty per cent of the interviewees felt that more trainings by NGOs could greatly contribute to an improvement of their knowledge. Nineteen per cent of the respondents stated that trainings in general would support their knowledge expansion, and another 19 % specifically listed trainings or advice from the government side as a desired source of knowledge. Sixteen per cent of the farmers mentioned that an establishment of more farmers groups could help them to increase their knowledge. Nine per cent of the respondents explained that the practical application of methods learnt from trainings would achieve this purpose, and another 9 % of the interviewees listed trainings from institutions as a possible source of knowledge expansion. Seven per cent of the farmers stated that in their view, funding would help to improve farmers' knowledge, for example through monitoring and evaluating farmers' practises and perceptions or through enabling them to expand their own projects. Seven per cent of the respondents were of the opinion that the provision of inputs could contribute to knowledge expansion, such as hybrid seeds or pesticides. One farmer stressed that the provision of equipment would be more helpful than financial support. One interviewee suggested that the organisation of more farm visits would help to improve his knowledge, and in a focus group the idea of supporting exchange between groups of different sub-counties was brought up, which could be organised through the group coordinators.

The topics on which the farmers expressed their wish to acquire more knowledge were technical knowledge (19 % of the respondents), indigenous methods (7 % of the respondents), pest control (7 % of the respondents), organic farming and environmentally friendly methods (5 % of the respondents), water harvesting (2 % of the respondents) and animal production and management (2 % of the respondents).

Over 40 % of the respondents stated that an improved exchange between farmers and universities would be highly beneficial. One farmer explained that she would be ready to mobilise group members if such an opportunity was offered. One respondent explained that universities could provide theoretical knowledge and advice for agricultural development and another farmer suggested that they could pass on whatever they have collected in terms of indigenous knowledge. None of the respondents stated that any form of exchange existed so far and one farmer stressed that the knowledge of universities does not reach the farmers.

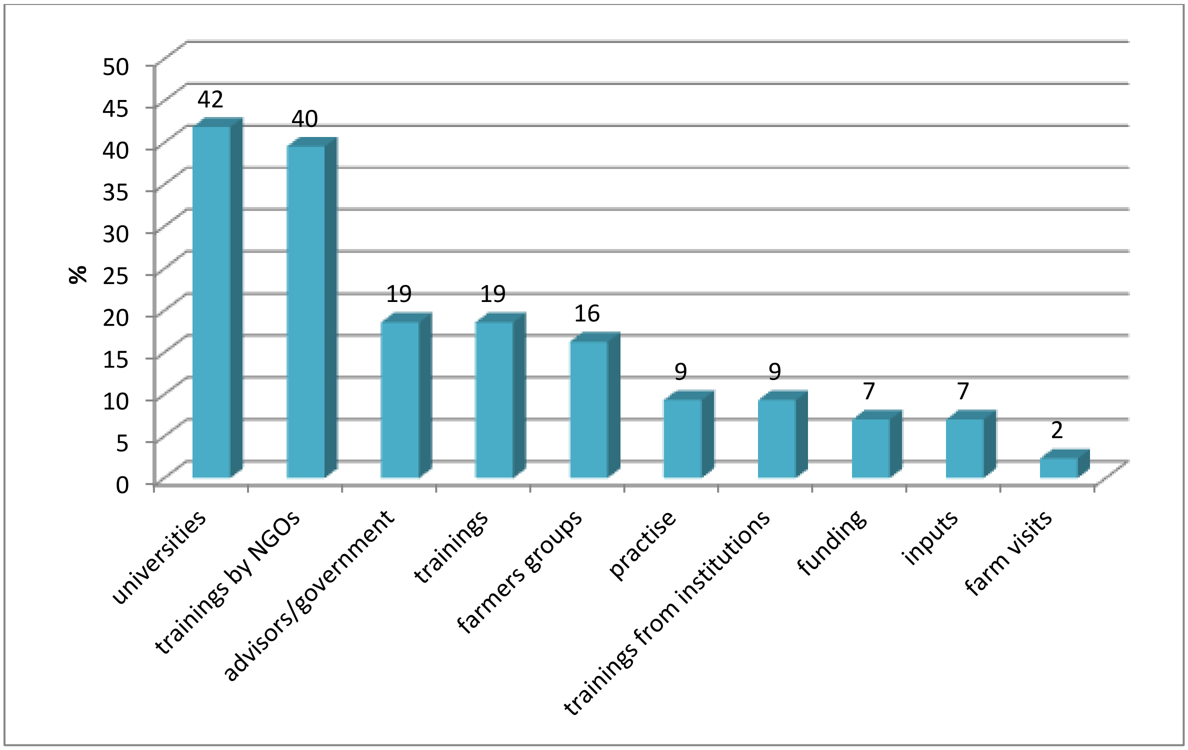

Figure 24: Possibilities to improve knowledge listed by farmers (maximum value of y-axis set as 50 %)

6.2 Results from interviews with staff from non-governmental organizations (NGOs) and advisory staff from the government

The interviewees from NGOs and the government shared their knowledge about problems of the farmers from a wider perspective. The results from their interviews are described in the following.

6.2.1 Vi Agroforestry

Victor Komakech has been the "Environment and Climate Change" coordinator at the "Swedish Cooperative Centre-Vi Agroforestry (SCC-Vi) Eastern Africa" since 2003. The office is located near Masaka Town and thus works in three districts. He gave general information about the NGO and his colleague Matthias Masiga added information about his unit, "Organisation and Development", which helps farmers with lobby issues. Victor Komakech explained that the units of Vi Agroforestry are "Environment and Climate Change", "Farmer Enterprise Development", "Organisation & Development" and "Financial Services" and that there is a programme for children and youth groups called "Farmers of the Future". The "Environment and Climate Change" unit is subdivided into the subunits "Environment and Climate Change" and "Sustainable Agricultural Land Management practises", which comprises education in agronomic practises, Agroforestry, water management, nutrient management, efficient energy, animal management and husbandry and tillage & residue management. Furthermore, there is a "tree seed store" from which farmers can obtain seeds and receive training in seed collection.

As one of the main problems of the farmers, Mr Komakech listed the lack of technical expertise, stating that for example there was only one entomologist in the whole district. He explained that the sub-county officers had a very low facilitation by the government, for example that there was even a lack of financial support for fuel for motorcycles, and that the accessibility to resources was also lacking for farmers due to the cost of resources itself and due to transport costs. He furthermore explained that there was a gap between research and "on-ground" work. For example, a lot of research had been done about the coffee twig borer, but the knowledge did not reach the farmers. Mr Masiga added that the government structures at the district level were very weak and many officers were not well facilitated and did not go to the field to help farmers. Lastly, Mr Komakech explained that many of the farmers who got the knowledge, still did not follow the recommendations and continued their poor farming practises. For example, they were negligent about farm hygiene or removing affected plants as they had a resistance to destroying their plantations.

Climate change and the introduction of alien species had increased the number of pests and diseases, and their resistance against chemicals had enforced the trend towards modern methods. He explained that traditional knowledge had been lost due to the trend towards modern methods, especially in places with good extension. Environmentally seen, traditional methods were most preferable, but in his view, integrated pest management was the best option for farmers, as organic methods alone were not effective enough.

In relation to the spread of knowledge between farmers, he stated that most farmers did not believe in learning from other farmers but preferred to learn from a "new face". He explained that they often did not even know the practices of their neighbours, as they had no faith in each other. Structures such as study circles and demonstration farmers were thus good tools for the spread of knowledge and the increase of collaboration. Matthias Masiga added that many farmers did not even trust NGOs as they had had bad experiences with them so that it took Vi Agroforestry time to build trust.

As only extension officers had access to computers and internet, Mr Komakech stated that the reinforcement of extension was very important. Furthermore, agriculture should have a higher priority within the government so that not only funding will be planned, but also monitoring needs to be strengthened to ensure the right use of the funds. Media such as the radio should be used more and services should be brought closer to the farmers, for example by creating outlets of companies, which are located in Kampala, in the communities of the countryside.

Figure 25: The entrance to the office of Vi Agroforesty in Masaka, Uganda (picture: Johanna Unger)

6.2.2 Joseph Mary Male

Joseph Mary Male was the only interviewee who had served as a field extension officer. He also had a National Diploma in Farm Management from an Agricultural College and he used to guide workshops for capacity building in "St. Jude Center for Sustainable Integrated Organic Agriculture". He had been the farm manager of Katigondo Seminary for half a year and was able to share problems specific to the Masaka region as well. He explained that the soils in this region were fertile, but that the population had raised and the climate had changed. Additionally, earlier generations had been using more methods of soil conservation, natural materials and non-toxic methods, whereas nowadays they were using polythene materials and chemical pesticides, which were making pests resistant. He furthermore stressed that the government was not giving priority to agriculture. He stated that the Masaka region used to be ahead of other regions in terms of agriculture, but wilts had been deteriorating the products in recent years, especially coffee. He also mentioned that many indigenous seeds were not available anymore, which had lead to an increase in pests. Furthermore, the climate change had led to the same situation, as the heat was favouring certain pests.

He explained that farmers groups were most effective if they had a size of 20 to 25 members and that the shared knowledge would reach around 100 people if every member shares it with their families. To reach farmers, the best way was to speak on weddings, in churches and mosques or through mouth propaganda. To reach farmers who were not able or willing to attend groups, radio programmes were a good source of information. Farmer group members were often women who were more “humble” and “softer” than men.

He furthermore presented examples of posters which were provided in collaboration with different organisations such as Kulika Uganda, the FAO (Food and Agriculture Organization of the United Nations), EPOPA (Export Promotion of Organic Products from Africa), Send a Cow, Heifer International, Caritas, SATNET (Sustainable Agriculture Trainers Network), NOGAMU (National Organic Agricultural Movement of Uganda) and JIDDECO (Jinja Diocesan Development Coordinating Organization) to explain practises such as the construction or production of “Tip Taps”, Fuel Saving Stoves, Sack Mounds, Kitchen Gardens, Healthy Food, Compost, Liquid Manure, Natural Pesticides and “Plant Tea”. The posters presenting the production of a Natural Pesticide and “Plant Tea” are depicted in Figure 26 and 26.

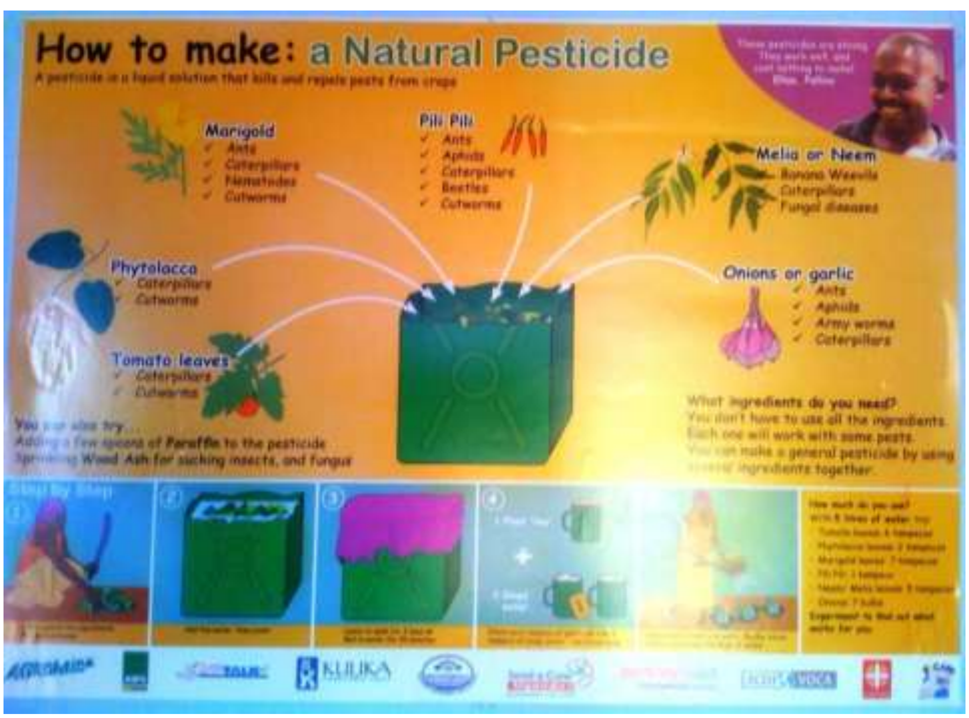

Figure 26: Poster provided by NGOs about "How to make a Natural Pesticide"

Figure 27: Poster provided by NGOs about "How to make Plant Tea"

6.2.3 Uganda National Farmers Federation (UNFFE)

Kenneth Katungisa from the Uganda National Farmers Federation (UNFFE) was interviewed at the 21st National Agriculture and Trade Show which took place from 8th to 14th of July 2013 in Jinja. He had completed a Bachelor of Science in Environment at Makerere University and he had worked for UNFFE for six years since then. He had started as an Executive Assistant in 2008 and has been in charge of "Climate Change and Environment" for five years. He has been training farmers in technologies and raising awareness of climate change. 74 districts and 94 organisations are members of UNFFE.

He explained that the Masaka region was a dry area and the majority of the farms were quite small (3,5 acres on average) in comparison to other districts. The extension system has been dominated by NAADS and was weakened when the component of input distribution was introduced in 2001, as the farmers became more interested in receiving inputs instead of extension. However, this decision was being reviewed and bringing extension services to the sub-county level was being discussed.

Climate change has lead to an increase in pests and diseases, especially cassava mosaic virus and bacterial banana wilt, which has wiped out whole plantations in some areas. Most traditional knowledge was dying with the old people, and 60 % of the population was uneducated, so that the knowledge did not reach young people. Additionally, there were not many young people in the agriculture sector, as they mostly moved to the towns and cities.

He stated that farmers in Uganda were using a low amount of chemical fertilizers compared to other countries (1 kg per hectare on average). However, Mr Katungisa had interviewed 100 households in Mukono district and found that 90 % of the farmers had stated that they used artificial fertilizers or pesticides. This was indicating a trend towards an increasing use of pesticides. At the same time, most farmers were only learning from other farmers how to apply pesticides and did not have any professional source for this knowledge.

There were self-made farmers groups and farmers groups set up by NAADS. Self-made farmers groups were usually formed along a specific commodity, such as coffee, maize or bananas. They were usually set up very democratically and survive due to the interest of the farmers. Farmers groups formed under NAADS usually did not continue when NAADS stopped providing inputs to the farmers.

Mr Katungisa stated that there was hardly any exchange neither between universities and farmers nor between farmers and researchers. Thus farmers were not informed how to manage new diseases and pests. Furthermore, new technologies were difficult for the farmers, as they were mostly old and illiterate people, and the young people had left the countryside for the towns. UNFFE had been trying to build platforms for farmers and researchers to meet, but funding had been a problem. Generally, it was also difficult to reach farmers as some areas did not even have electricity, though most were having phones. Furthermore, university graduates often did not work in the same field they studied due to the high unemployment rate.

6.2.4 Kulika Uganda

Joseph Mugagga has been working for Kulika Uganda since 2000. He studied agriculture at Reading University in the UK with a scholarship from Kulika and worked for other NGOs such as TOCIDA (Tororo Community Initiated Development Association). Kulika trains farmers in sustainable agriculture and helps them to use and recycle all available resources such as animal manure and urine. They also teach the farmers how to take care of the soil, how to plant trees, and how to properly dispose of farm waste and separate biodegradable and non-biodegradable waste. There are residential trainings with 20 participants, which take place once a week every month for six month, and non-residential trainings which also run for six months.

Mr Muggaga stated that the Masaka region used to be known for plantain production, but due to the loss of soil fertility and banana wilt, farmers had been changing to other crops. Due to the proximity to Victoria Lake, the district was less dry than other districts in East or North Uganda. The loss of soil fertility was due to the lack of crop rotations, the practice of bush burning, overgrazing, lack of knowledge about soil and water conservation and deforestation. Furthermore, due to the population growth, the use of fallows had become much rarer. Fertile soil would encourage the vigour of plants and make crops more resistant against diseases, thus compost and plant tea were recommendable.

Natural pesticides are neem (*Azadirachta indica*), tomato leaves, ash, African marigold (*Tagetes erecta* L.), hot pepper, *lantana* leaves, *phytolacca*, *Tephrosia* leaves and onions (*Allium cepa*). Generally, farmers had a lack of knowledge about such methods as they did not share knowledge or attend meetings and groups. Furthermore, there was a lack of a link between extension workers, which was creating confusion for farmers. Instead of working separately, all extension workers should be connected by a higher instance and farmers should have the possibility to choose between different ways of capacity building.

Due to the hot climate which was partly enforced by deforestation pests spread fast, encouraging farmers to use chemicals. At the same time, many farmers could not afford chemicals and only used them when they were provided by the government or by NGOs. Farmers would not read instructions and this made the use of chemicals dangerous for human and plant health.

6.2.5 Send a Cow Uganda

Christopher Kyeswa and Claire Nsubuga Namutebi were interviewed in the office of "Send a Cow Uganda". Christopher Kyeswa had been working for "Send a Cow" for eight years and he had been the Programme Manager for six years. Mrs Namutebi is in charge of the Central Zone and overseeing the Livestock programmes and Social Development. The NGO is mainly agriculture oriented, but also pursues a holistic approach with a focus on developing human capacities.

Mrs Namutebi explained in Uganda, the main pests were caterpillars and aphids on vegetables and sweet potatoes, fruit pests on oranges and mango flies, banana weevils, bacterial banana wilt, coffee wilt, bacterial wilt, blight and flies on *Soloanaceae*, the groundnut rosette virus, the cassava mosaic virus and striga on cereals in the eastern part of the country. The most important traditional methods of pest management were taking care of the soil fertility, early planting, using organic pesticides, biological control and physical control and teaming and monitoring the different pests. Many farmers were not using chemicals in a safe way, but there were many concoctions from wild plants available, for example *tithonia*, *Tephrosia vogelii, phytolacca*, neem (*Azadirachta indica*), garlic (*Allium sativum*), African marigold (*Tagetes erecta*) and chilli (*Capsicum frutescens)*. Animal urine and woodash could also be used, even as fertiliser, and human urine was allowed on bananas and coffee, but not on vegetables. Another method was by-planting or intercropping, for example of garlic or onions in carrots against the carrot fly, basil plants (*Ocimum basilicum* L.), African or American Marigold in banana plantations against nematodes and *moringa* (*Moringa* spp. Adans.) against nematodes as well.

Mr Kyeswa stated that over 80 % of the population of Uganda was dependent on agriculture and 70 % of small holder farmers were women who required the support of the men, especially in terms of food security. However, men were more interested in marketing, which is why the NGO has "social development" as a part of their programme, which provides trainings in gender roles and encourages the men to support the women. Uganda was furthermore having the second highest population growth in the world, which caused a reduction in land size through constant subdivision. This development was causing urban migration and the emergence of slums in towns and cities. The NGO was thus supporting "semi-intensive" production on farms of sizes of two to six acres and teaching farmers how to produce food sustainably by integrating livestock and using manure and organic fertilisers. They were also experimenting the “push and pull” method in collaboration with NARO (National Agricultural Research Organisation).

One of the main problems in the Masaka region was an almost dysfunctional government extension service especially due to a lack of budget. Mr Kyeswa explained that only around three to four per cent of the National Budget goes into actual production. Also, even though structures are present, there was a lack of facilitation such as fuel for motorcycles or salaries for district directors. Another problem in the region was a lack of quality in planting material and thus seed security. “Send a Cow” wanted to set up community seed centres, but farmers who had seed did not want to contribute. The seed provided by seed companies often were of no good quality or sold as hybrid seed even when they were not. Furthermore, climate change was posing a threat in the form of unpredictable rains, hailstorms and floodings. Also, there was the problem of an unclear marketing structure and disorganised farmers. Thus, there could be a lack of food in one region and an overproduction in another region at the same time. Cooperatives did not exist anymore as farmers had been suspicious of them. He also stated that there were many bodies of water, but a lack of irrigation, which made agriculture very vulnerable in this region. Lastly, there was the problem of a lacking land policy, which caused big estate dealers to buy arable land and build houses on it.

One of the reasons for the loss of traditional knowledge was urbanisation. Children were furthermore not having time to learn from their parents and schools were not training farming skills. Lastly, the average life expectancy in Uganda was 59 years so that the old generation had already died with their knowledge.

Mr Kyeswa explained that chemical pesticides affect the soil fertility and thus productivity. Furthermore, they represent a danger to children and they are only effective on the short term, because resistance can arise on the long term. Chemicals were often mixed rather than pure and the supply was not consistent. The government was not imposing taxed on chemicals which was making them cheap. They were easier to use than traditional methods even though they required protective clothes. Some farmers were assuming that the increase of cancer was due to chemicals.

6.2.6 Heifer International

Richard Wanyama from Heifer International was interviewed in the office of the NGO in Kampala. He has been working for the organisation for six and a half years as a Lifestock Specialist.

He explained that the NGO works through community groups and gives livestock to farmers after an elaborate preparation in which it teaches feeding, health management, housing of animals, marketing of milk, sanitation and hygiene and the basic nutrient supply of each family through vegetable gardens. Since most farmers have little land, the zero-grazing concept is promoted. After the farmers have received the livestock, they are provided with intensive follow-up trainings. Furthermore, the NGO has constructed biogas plants with the help of a grant from the government and supports climate change mitigation techniques such as the introduction of drought resistant crops, water harvesting capacities, the planting of trees and post-harvest handling to limit losses after the harvest. The "East Africa Dairy Development" project (EADD) provides trainings to smallholder dairy farmers on business and dairy practices to double their incomes through improved breeds, feeding and general husbandry. African Breeders Services and the World Agroforestry Centre (ICRAF) are partners who provide improved breeds and improved feeding respectively. In the Masaka region, there are ten cooperatives called "Dairy Farm Business Associations" which receive trainings from Heifer for six months up to one year.

The Masaka region was rather favourable to pests due to the high amount of rain and heavy thicket. The most serious problem in terms of animals were ectoparasites, such as ticks, which cause fatal tick-borne diseases expensive to treat. This problem had been made worse through the introduction of "exotic" cattle which does not have the same resistance as indigenous cattle. Tse-tse flies also posed a problem as they were affecting productivity. The third biggest problem on livestock in the region were worms and flukes. Less serious pests were fleas, mites and lice.

The inappropriate use of alcalicides had caused ticks to develop resistance. In the past, bush clearing and spraying had been used as control methods. Due to the population growth, these methods are not available anymore. Furthermore, the increase in coffee plantations had been providing bush and shade to tse-tse flies. Tse-tse traps were an effective method; however, they had not been used to a sufficiently extensive level due to the lack of commitment from the farmers. As the Masaka region was part of the big "cattle corridor" reaching from Tanzania to North Uganda, efforts to eradicate pests had to be regional.

People who had traditional knowledge were not willing to share it as they wanted to use it for their own benefit. Furthermore, there was no documentation and people just died with their knowledge. Lastly, the Church had been judging some traditional practices as "demonic" and thus caused people to reject these methods.

Farmer groups were facing the problem of conflicts and different levels of participation as well as gender issues. Generally, men did not participate as much as women or did not want to be led by women. Due to the culture, women were not supposed to leave the men and this was hampering an all-inclusive development. They were also not allowed to control resources of high value. Furthermore, a problem was that young people rather preferred earning easy money to staying on the land. Lastly, there was the problem of governance, as many of the leaders were behaving immature or dictatorial.

Figure 28: The Values of Heifer International (picture: Johanna Unger)

6.3 Reflections on the data gathering process

There were three different settings of data collection – interviews with individual farmers, focus groups with farmers and interviews with staff from the government or non-governmental organisations.

As most farmers were met in the context of farmer group meetings which had their own schedules, the time for the interviews and focus groups were limited and did not allow the application of additional tools apart from farm walks, which helped to visualise the information provided in the interviews. The bias was thus put on gathering information from as many different groups and locations as possible rather than gathering information in different ways from few locations. Yet, it can be argued whether the sample size is big enough to be representative for the region. Furthermore, most of the locations for interviews were situated in Kkingo sub-county, as these locations were the easiest reachable from Masaka town and it can also be assumed that Mr Kalanzi had most personal connections within this sub-county. Some of the interviewees were his relatives or family members. To get a slightly broader impression, I requested to visit another sub-county which turned out to be Mukumgwe sub-county, which indeed gave different results than the research in Kkingo sub-county. Thus, it has to be borne in mind that this research is mostly representative for a specific area within the Masaka region. For example, J. Mwine (2010) found that specific sub-counties of the Masaka region, which are leading areas in organic farming adoption also exhibit an extensive use of botanicals for pest management, among which Kkingo sub-county is not listed. In addition to that, only small-scale farmers were interviewed and it can be assumed that bigger farms would, for example, resort to chemical pesticides to a larger extent. Amongst the interviewees there were quite big variations in knowledge about traditional methods, especially depending on whether training had been received from NGOs or not. For example, Mayanaga Immaturate who was interviewed in Kjaboggo Village had been trained in sustainable agriculture by Send a Cow and showed a broad knowledge on natural pesticides. Furthermore, the selection process of locations naturally contributed to the fact that most respondents were taking part in farmers' groups. No differences in the results about traditional knowledge were found with regard to gender or location.

For both the individual interviews and focus groups the help of a translator was required. This had many benefits, such as the fact that the interpreter introduced me to the farmers' groups and to each individual who was interviewed. Judging from the submissive reactions of most of the farmers towards me, they would not have opened up to me if I had asked them for interviews on my own, thus the translator also served as a middleman on a personal level. At the same time, the replies by the farmers often seemed longer than the translation and side comments were often omitted, including humorous remarks. Especially in the group discussions I felt that it was difficult for the translator to listen and translate at the same time as he also tried to gather the content of the discussions, which was less predictable than in the individual interviews. Furthermore, as he was well acquainted with the questions, he sometimes took over the lead of the interview, which I needed to prevent in order to be able to ask probing questions when required. In hindsight I realised that I sometimes should have insisted on more precise answers, for example a differentiation between the number of family members and people working on the farm. Another example would have been to ask more precisely about the fruits grown when only "fruit trees" were mentioned, and to enquire more deeply about local or minor crops, such as vegetables, since often only cash crops or staple crops were listed. Additionally, I could have asked to differentiate between local and exotic cattle breeds. Sometimes answers to later questions revealed details about answers given in previous questions, such as pest management methods named for crops which had not been listed to be grown on the farm initially. The fact that all farmers were interviewed by both a man and a woman makes it difficult to discern whether there would have been different reactions by different genders. I observed that many farmers reacted positively on meeting university staff; at the same time, this could have contributed to the 'deference effect' as described by Bernard (2006), which implies that responses by interviewees are influenced by their perceived status of the interviewer. Recording the interviews and focus groups with the farmers was unnecessary in retrospection as the requirement of translation provided me with enough time to take notes, though the recordings were helpful to reconfirm information or to fill gaps.

Normally only individual persons were interviewed, apart from one occasion on which a couple was interviewed. In the first location I interviewed both the husband and the wife of the same farm and this has been considered in the evaluation of data to avoid double counting. As individual interviews were mostly conducted on the occasion of group meetings, the farmers not being interviewed were often required to wait for long time intervals. Bringing questionnaires to be filled in the meantime might have given them a task in these periods even though illiteracy might have hampered this idea. In hindsight I found that enquiring about the education level could have been included in the first interview question, though the farmers may not have been very open about this information. In the individual interviews, many additional and probing questions were required just in the sense of semi-structured interviews, as the farmers often did not say more than what was required to reply to a question. In the interviews with staff from organisations the opposite was the case and very few questions were necessary to incite extensive replies even about related topics. Generally farmers brought up more new topics by themselves in the focus groups; however, as expected there were often few specific individuals who led the discussions. When interviewing individuals from groups, I frequently faced the question of how far away from the group to position myself and the interviewee, since I knew that other participants are listening might have influenced the replies by individuals. This phenomenon is also described as the Third-Party-Present Effect by Bernard (2006). In retrospection, I would have taken more pictures and made more notes to better remember the locations, groups and individual farmers.

According to Bernard (2006), the participants of a focus group should be more or less homogeneous and should not know each other. These conditions could not be fulfilled, as the members of the focus groups were members of farmers' groups at the same time. It can thus be assumed that the familiarity amongst the group members caused inhibitions of disclosure (Bernard, 2006). Furthermore, as Mr Kalanzi served as a translator, he also partly guided the discussions and my ability to encourage quiet group members to talk or dominant members to hold back was restricted. However, I generally observed that farmers appreciated this opportunity to make their opinion known and even many initially reserved members made sure to voice their views at some point.

7. Discussion

The purpose of this research was to investigate, evaluate and record local knowledge applied by farmers towards management of crop pests and diseases in the Masaka region. The research questions were:

1) What are the main pests and diseases to be dealt with in the Masaka region and what are the main crops affected and how/when are they affected?

2) What are the main indigenous methods of pest and disease management in this region?

3) How effective are the methods applied by local farmers for pest and disease management?

4) Where does the knowledge of farmers about pest and disease management mainly come from?

5) What are the opinions of farmers and advisors about chemical pest management?

6) What are the possibilities for farmers to improve / extend their knowledge about pest and disease management?

Having set out with a focus on the first three research questions, over the course of the research, the relevance of the fourth, fifth and sixth research question became more apparent. The roots of the problems which the farmers were facing were not to be found in a shortage of available methods of pest and disease management or their effectiveness, but rather in a lack of access to the knowledge related to the methods and their right way of application. This core problem was found to have several causes at its root. The following sections will discuss the results by investigating the reasons behind the problems found, and possible solutions to them.

7.1 Management of pests and diseases

Section 2.3 has shown that there is a wide range of pest and disease management methods, and that cultural and preventive methods play an important role. The original purpose of this research was to focus on the use of pesticidal plants. However, as described by Zehnder *et al*. (2007), there are various other methods used in organic farming with a higher priority, and insecticides of biological and mineral origin is a fourth-phase strategy which is used as a last option when all methods used in the preceding phases have failed.

The respondents primarily listed cultural methods and methods of farm and field hygiene such as the uprooting of dead stems or removing weeds for the management of the banana weevil. Such methods are described as the methods with the most long-term effects in the literature. Similarly, both in the literature and in the farmer interviews phytosanitary methods played a major role for the management of bacterial banana wilt and coffee wilt. However, it can be noted here that as one of the respondents stressed the laboriousness of the practice of these methods, they are unlikely to be adopted by small farmers who are lacking labour force. A related issue was touched upon in the literature regarding the maize stalk-borer, whose management through cultural methods is restricted due to the different farmers' preferences and practises. Trapping, which is also recommended by scientists against the banana weevil, was listed by only one farmer, and methods of habitat management and biological pest control were not listed by any respondent. Pesticidal plants listed by the farmers against the banana weevil were *phytolacca*, pepper (*Piper nigrum*), chilli (*Capsicum frutescens)*, *Aspilia Africana* and tobacco (*Nicotiana tabacum*), none of which were described in the researched literature. Similarly, while a lack of research about management methods of the banana wilt was stated by scientists, the respondents listed various methods such as the application of cattle urine and cow dung, woodash, and pesticidal plants, e.g. *Tephrosia vogelii*, Mexican Marigold (*Tagetes minuta*), *Phytolacca dodecandra* and Chili pepper (*Capsicum frutescens)*. Mwine *et al.* (2010) observed the need for research to elucidate the chemical composition of the pesticidal plants used and to evaluate specific pests managed by particular plant species through efficacy studies. Woodash was not mentioned in the researched literature for the management of the banana weevil and vegetable pests, though it was one of the main methods listed by the farmers. On the other hand, neem (*Azadirachta indica*), which is a recommended biopesticide against the banana weevil, the maize stalk-borer, vegetable and fruit pests and storage pests, was not known to any interviewee, though its use as a pesticide is also described in the Uganda Environews (UNDP, 1997), and it seems to be used in other sub-counties of the district as described by Mwine *et al.* (2010). For the management of vegetable pests, pesticidal plants were mentioned both in the literature and listed by the interviewees. On the other hand, the method of the use of natural enemies was not known to the farmers. For storage pests, many pesticidal plants suggested by researchers were not listed by the respondents. At the same time, the use of cypress leaves which was the second most common main method listed by the farmers and described by them as effective, was not stated in the literature recommending pest management methods. The enhancement of soil fertility and thus the nutritional status of the crops was listed as a method for the management of the banana weevil, the coffee weevil and the maize stalk-borer by the literature and for the management of banana wilt and the maize stalk-borer by the interviewees. The respondents also used herbicides in order to increase the vigour of their crops and thus diminish the impacts of the coffee weevil and the maize stalk-borer.

The incongruences found between the methods listed in the literature and the methods named by the interviewed farmers allow two conclusions. Firstly, it seems that research has likely been focussing on quantitative experiments and neglecting recording and validating the knowledge of farmers, especially with regard to the use of pesticides of biological or mineral origin (pesticidal plants and woodash). Secondly, much knowledge could be found in research which is not reaching the farmers, as for example integrated pest management, the “push-pull” strategy, or any methods which involve natural enemies or the use of neem (*Azadirachta indica*). Thus, the dissemination of knowledge to farmers as well as an increased collaboration between farmers and researchers should be a priority of scientists in future.

Even though pesticides are highly unrecommended for the management of the banana weevil in the literature, they were used by 16 % of the interviewees. They were also applied against coffee wilt and the coffee weevil by some respondents, though they are described as ineffective in the literature. It can be noted that the farmers who applied pesticides had very little knowledge about their application. Accordingly, only the lack of knowledge about chemicals and possible alternatives led to a neglect of cultural methods or biological control which would have been more appropriate to manage the pest. This can also be seen from the fact that most farmers described traditional methods as more effective than chemical one. There seemed to be few farmers who combined pesticides and traditional methods in the logic of integrated pest management, which is for example highly recommended for the management of the maize stalk-borer. This confirms the lack of knowledge transfer between researchers and farmers.

Lastly, it can be noticed that the pests and diseases had often been occurring for very different time intervals in different locations; this was especially true for those diseases which were stated as major problems by most farmers, i.e. banana wilt and coffee wilt. Considering that none of the locations had a considerable distance from each other, there are likely many factors which influence the spread and prevalence of pests and diseases at a local scale, which have not been sufficiently investigated. It might thus be worthwhile to invest into such research, also as many of the pests and diseases pose rather recent problems which have not yet been sufficiently covered by science under the local circumstances.

7.2 Indigenous knowledge

Fifty-one per cent of the respondents had named their parents as a source of knowledge and 47 % had explained that they had learnt pest management methods from them. However, it was also explained that the previous generations had not faced as many pests and diseases and also that new pests and diseases had been introduced to the region in the meantime. Thus, many of the methods adopted from the parents referred to general methods such as farm hygiene rather than specific methods, especially pesticidal plants. Knowledge about pesticidal plants was mostly acquired from trainings by NGOs, such as described by the farmer in the first location who had been trained by Send a Cow, and as expressed by the poster about the preparation of "plant tea" created by different NGOs. For the banana weevil, for example, only the use of woodash was described as a method adopted from the parents, while the application of "plant tea" had been learnt from educational staff from NGOs. All in all, 56 % of the interviewees had stated that they had their knowledge about pest management from NAADS trainings and extensionist visits. As discussed in section 2.4, indigenous knowledge implies knowledge which has been handed down over generations within a community (FAO, 2005). Local knowledge, by contrast, is a wider concept allowing influences from the outside which have become part of the local practises and belief systems (ibid). Warren (1991) defined indigenous knowledge as knowledge which "contrasts with the international knowledge system generated by universities, research institutions and private firms", whereas according to the FAO (2005), it is important for those involved in research and development processes with local communities to see local knowledge as one component within a more complex innovation system. Thus, it can be stated that there is less indigenous knowledge and more local knowledge available to the farmers today. The reasons for this can be found both in the literature and in the statements of the interviewees, as elaborated in the following paragraphs.

In many parts of Uganda, animal husbandry and agroforestry have been practised for hundreds of years (Kintu, 1996). Through the observation of successes and failures, farmers have promoted or rejected certain crops or techniques without scientific explanations, and only today indigenous knowledge practises are recorded and scientifically explained (*ibid*). However, as Ankli *et al*. (1999) and Gradé *et al.* (2007) note, traditional knowledge such as of herbs, is usually in the hands of a small group of people who guard it jealously for their advantage. Furthermore, it is often not documented but passed on between generations by word of mouth or observing elders' activities (Mwine *et al.*, 2010). Accordingly, the only knowledge referring to pest management handed down to the interviewees by previous generations were preventive practises of crop hygiene. However, very little knowledge had been inherited about the management and treatment of pests and diseases once they occurred.

Another major problem contributing to this situation is the fact that new pests and diseases have been introduced to Uganda and Masaka region. All the interviewees who made statements about the time span of how long they had been affected by various pests or diseases did not mention anything beyond ten years, apart from one statement about the banana weevil. Several respondents mentioned that the pests or diseases had been affecting their farms strongly only recently. Thus, the farmer generation of today has no traditional knowledge how to tackle these problems, since their parents did not face them. Mr Kefa Kalanzi had furthermore elaborated that due to the climate change and to the variations of land use through the government and land fragmentation, the traditional knowledge from ancestors have become irrelevant for today's farmers. As most farmers have to sustain themselves on the basis of very small areas, they are forced to try and achieve high yields, which however is at the cost of soil fertility and the sustainability of their farming systems. According to Mr Kyeswa, urban migration is another factor contributing to the loss of traditional knowledge as young people have been leaving rural areas and are not adopting knowledge from their parents anymore.

To summarise, a lack of documentation and knowledge transfer from ancestors, the introduction of new pests and diseases and a new environment due to climate change and land fragmentation have led to a lack of self-reliance of farmers in terms of their knowledge. These results highlight the need of a much stronger support from both official and non-official organisations to provide farmers with training on methods adapted to their present-day problems.

7.3 Chemical pesticides

The interviewed farmers showed a limited knowledge about the adverse effects of chemicals and often applied them to crops which were to be sold, but not to the crops grown for home consumption. It became clear through the interviews that farmers who have received or attended less trainings from NGOs tended to resort to chemical pesticides to a much larger degree than farmers who had been trained in alternative methods. Generally, it could also be observed that it was mostly farmers with little or no knowledge about management methods who used pesticides. Governmental trainings such as provided by NAADS were stated to encourage farmers to apply chemical solutions whereas NGOs were said to promote traditional methods of pest management alongside methods of organic farming. As became clear from the interviews and has also been elaborated by Mr Katungisa from the Uganda National Farmers Federation, an additional problem is the fact that many farmers had no reliable sources of information on how to apply pesticides appropriately. This stresses the importance of traditional knowledge and the efficiency of teaching natural management methods instead of providing pesticides without very precise instructions on how to apply them. Even though few farmers stated that they read the instructions on the containers, it can be assumed that many cannot do so due to illiteracy.

Alternatives are radio programmes, which were listed as a source of information by one interviewee and also suggested by Victor Komakech and Joseph Mary Male in their respective interviews. Mr Muggaga from Kulika Uganda stated that some farmers were not reading instructions for pesticides, but using them more and more due to the increased spread of pests. Thus, wrong application methods can contribute to the adverse health and environmental effects of pesticides. Mr Kyeswa stated additional problems of mixed instead of pure chemicals and inconsistent supplies. Due to these issues, farmers would benefit from being independent from external inputs by using traditional methods. However, as described in section 2.5, a favourable policy environment for creating a more sustainable agriculture is missing (Pretty & Röling, 1997). Simple extension of the message that sustainable agriculture can match conventional agriculture for profits will not suffice. Conversely, a necessary condition would be that large numbers of farming households become motivated to use coordinated resource management, such as for pest and predator management (*ibid*). Thus, for sustainable agriculture to succeed, policy formulation needs to be redesigned (*ibid*).

While natural methods were known for the management of crops to a certain degree, livestock was treated with chemicals to a large extent. Especially the so-called "exotic" races require many treatments since they are not adapted to the local conditions and climate, as has been explained by Richard Wanyama from Heifer International. This is reflected in statements by farmers who listed various problems with their animals and mostly used chemicals to treat them. It is noticeable that organic farming was generally only associated with crops and not with animals. It may be worthwhile for researchers and instructors in the agricultural field to consider these issues and explore more possibilities of more sustainable ways of animal husbandry.

7.4 Access of farmers to knowledge and indigenous knowledge and possible improvements of farmers' knowledge

"Academics who teach gradually distance themselves from the operational world; committed practitioners are drawn away from university life and thought." (Chambers, 1983,)

According to Altieri (2002), resource-poor farmers gained very little from the Green Revolution. As one reason, he names the peasants being excluded from services that would have helped them to use the new inputs, such as technical support, credit and information. Secondly, he states that the technologies were inappropriate for poor farmers, neglecting local participation and traditional knowledge in favour of modern scientific knowledge. Thus he concludes that a natural resource management strategy to benefit the poor more directly, needs to be based on the use of local resources and indigenous knowledge.

Many years have passed since Chambers and Jiggins and others with them highlighted the shortcoming of the TOT model of extension and argued for a new farmer participatory mode of agricultural research, development and extension (see Section 2.6). Nevertheless, many extension services are still based on the linear top-down model typified by TOT, and the findings of this research indicate that available information on promising pest and disease control practices fails to reach the farmers. As expressed by Swaminathan (1982),"The future of our agriculture (...) depends on the success with which we can help the small and illiterate farmers to take the many small steps which alone can lead to improved methods of farming."

Trainings by NAADS and visits by governmental officers were stated as the main source of information by the interviewees. However, at the same time many farmers also explained that there were no trainings in their area or that extension visits were not frequent, and the offered trainings appeared to take place with low frequencies. The contents of the trainings were mostly methods of conventional agriculture, and as the parents of the interviewees had not been facing the same problems as them, the most important source of information for traditional and natural pest management methods appeared to be non-governmental organisations.

The most active NGO in the region was Send a Cow, which had reached 26 % of the respondents, and the trainings organised by this NGO appeared to have a higher frequency than those arranged by the government. Farmers who participated in their trainings clearly exhibited knowledge of traditional methods. However, it was mentioned by a farmer that extension from NGOs did not reach many areas. Asked about desired knowledge, the interviewees mostly listed technical knowledge and indigenous methods, which shows that there is a clear interest in sustainable farming methods. Two respondents even listed organic farming and environmentally friendly methods specifically.

Farmers groups appeared to be a helpful source of knowledge for 30 % of the respondents, even though almost half as many stated that they were not participating in any group. Opinions about groups varied. Some preferred them to trainings or farm visits and found them to be conflict free. Others thought them ineffective due to the low participation of some farmers. Mr Muggaga had been observing a lack of participation in groups in his work, and Mr Wanyama from Heifer International stated that groups were facing conflicts and gender issues. According to Mr Male, groups are an effective tool of knowledge dissemination if the acquired knowledge is passed on to the respective families. Mr Katungisa explained that self-made farmers groups were more effective than those groups formed under NAADS. It can be assumed that farmers groups are an important tool in knowledge dissemination, but they can only be effective when sufficient trainings and knowledge transfer from experts is provided in the first place.

The interviewees were also very willing to contribute to an exchange with universities, but were not offered any opportunity so far. As Mr Katungisa explained, university graduates often do not work in the field they studied, which may contribute to the problem. The main root cause was described by Mr Komekech, who explained that although researchers own much knowledge about traditional methods of pest management, this knowledge does not reach the farmers. Often research projects also deal with singular approaches rather than using an integrated approach (Giller *et al.*, 2010), which is not appropriate for the complex problem faced by farmers. As expressed by Bean (2005), "The tension between studying big ideas that do not fit neatly into existing methods and studying safe and small ideas that produce predictable but trivial results creates a backdrop against which scholarship evolves." Research faces the conflict between finding disciplinary truth and finding out something useful, while researchers in a profession have as their purpose not to attain pure knowledge but rather praxis (Bean, 2005). It should be remembered that agriculture is a highly practical field and thus, an increased exchange between academics and practitioners can be considered a highly beneficial measure to improve farmers' knowledge. The ultimate test of the value of research to the public "will not rest with internal elaboration or with faculty members charming other faculty members; rather, it will be seen with improving understanding, teaching, learning, and organizing in a heterogeneous society." (Bean, 2005)

The remark by a farmer that the practical application of methods learnt from trainings would help to improve farmers' knowledge plays an important role in this context as well. It can be applied to all sources of learning in accordance with Kolb's Learning Cycle which describes that active experimentation and concrete experiences lead to reflective observation and abstract conceptualisation, thus the possibility to learn from the experience (Hofny-Collins, 2013) (Figure 29). This also makes it clear that for knowledge transfer to have a lasting effect on farmers' knowledge; training and information exchange needs to be frequent and regular, much as implemented by Kulika Uganda.

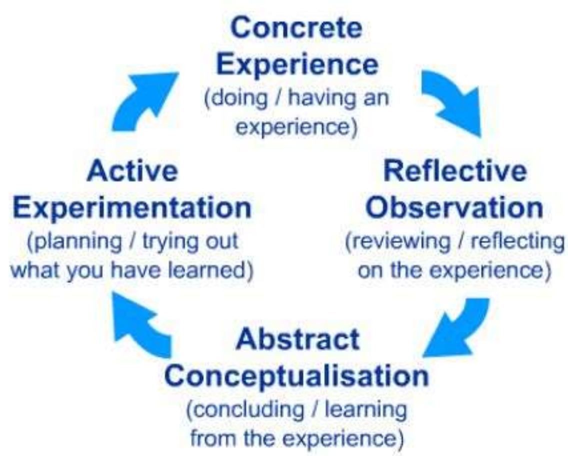

Figure 29: Kolb's Learning Cycle (Hofny-Collins, 2013)

All in all, it appears that only the combination of different measures can improve the knowledge of farmers with a lasting effect. The most important measures to be taken are a stronger focus on traditional methods in farmers' trainings, support of NGOs through the government and exchange between farmers and universities. Altieri calls for an integrated approach to agroecosystem management which is based on an understanding of the agroecology and ethnoecology of traditional farming systems (Figure 30) and addresses soil, water and pest management aspects simultaneously. NGOs are widely set up in a way that reflects such a systematic approach. For example, Vi Agroforestry has got various units addressing both agricultural practises and socio-economic issues of the farmers such as enterprise development, lobbying and financial services. They equally give importance to environmental issues through their "Environment and Climate Change" unit, which focuses on conservation of local resources as described by Altieri. UNFFE and "Heifer International" had similarly made climate change and the environment substantial parts of their work. "Send a Cow Uganda" furthermore combines trainings in agriculture with developing of human capacities, which is another cornerstone of an agroecological approach. It became clear from the interviews that there is a wide range of NGOs, but a lack of collaboration. Thus, a better organisation, networking and wider extension of their services should be supported.

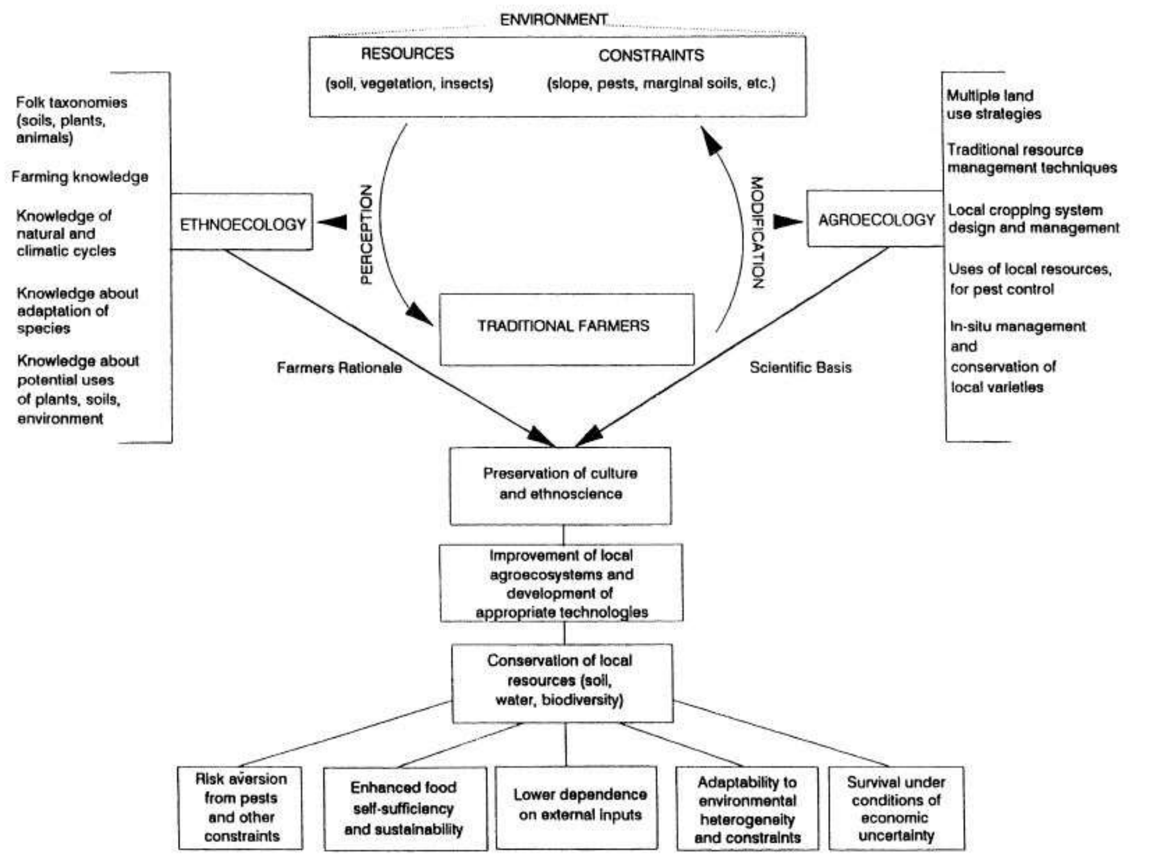

Figure 30: The role of agroecology and ethnoecology in the retrieval of traditional farming knowledge and the development of sustainable agroecosystems, including appropriate innovations in pest management (Altieri, 2002)

Mr Joseph Mary Male stated as a very central problem the lack of support for agriculture by the government. Also, a farmer mentioned that the government was not supporting projects for knowledge expansion. Mr Komakech and Mr Kyeswa described in detail that even basic support was lacking such as financial backing for fuel for motorbikes of extensionists or the provision of technical experts to the different sub-counties. According to Mr Kyeswa, only around three to four per cent of the National Budget go into production, even though some 80 % of the population are engaged in agricultural production. Mr Muggaga furthermore explained that there was a lack of organisation of the extension network, which is likely true for NGOs as well. Though the involvement of NGOs alongside the public sector in the extension system could be beneficial, the managerial confusion and inefficiencies resulting from extension staff having two masters in the field poses the risk of conflicts of interest (IFPRI, 2013). Furthermore, after the decentralisation, the number of extension officers was reduced to half and except for areas serviced by NGOs, districts are unable to cover the expenses of extension services (IFPRI, 2013). Apart from financial support, human resource can thus be stated as a highly needed requirement for the extension system on the organisational level and on sub-county levels, especially in remote and underserved areas. Research about pest management methods alone cannot benefit the farmers if their other constraints are not understood, or if the findings of research are not equally communicated to development agencies, extension services, governmental departments and international organisations so as to aid targeting of policy at all levels (Giller *et al*., 2010).

Figure 31 summarises factors that have been found to influence the loss of traditional knowledge and the increase in pests and diseases.

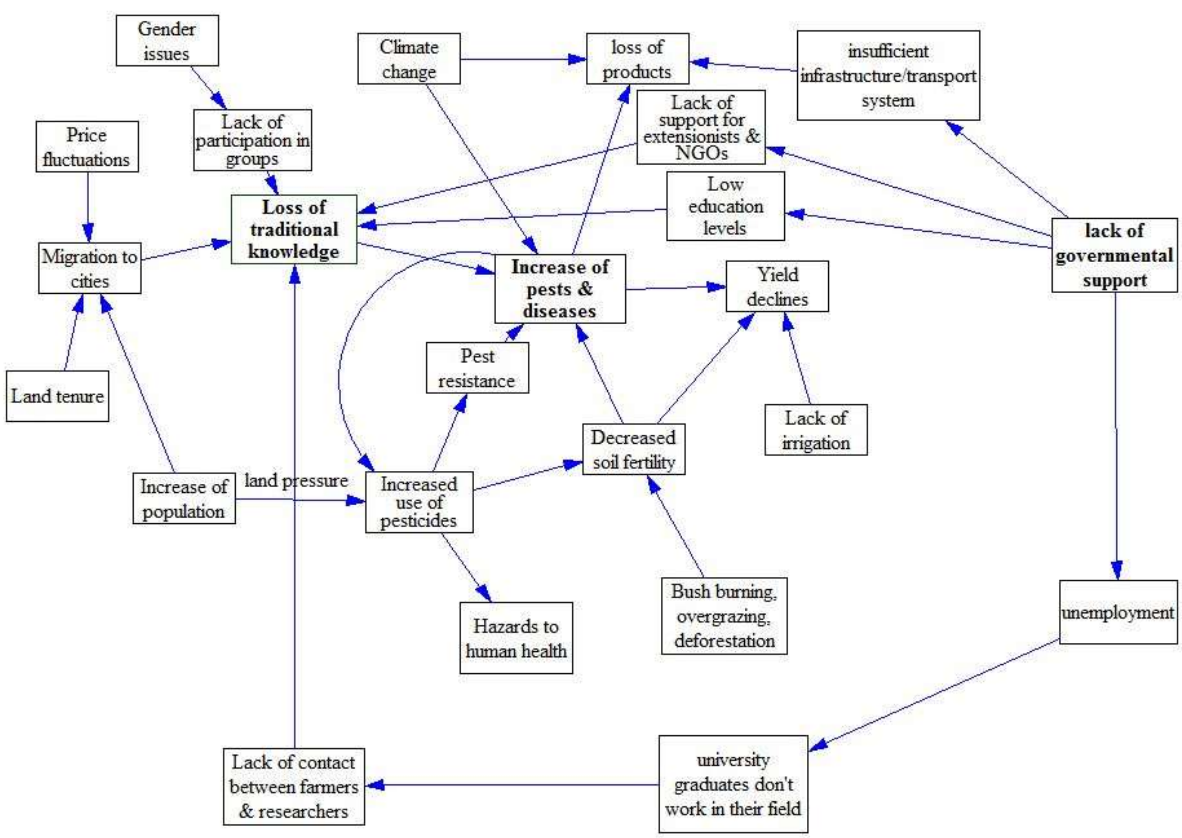

Figure 31: Causal diagram showing the factors influencing the loss of traditional knowledge and the increase in pests and diseases (source: this research)

8. Conclusion

'We see things not as they are, but as we are ourselves.' (Tomlinson, 1931)

This research set out to investigate, evaluate and record traditional methods of pest management in the Masaka region. During the course of its implementation, it became apparent that a few assumptions had to be reconsidered.

Firstly, it was found that there is hardly any indigenous knowledge available to the farmers due to a lack of knowledge transfer between generations, a lack of documentation, and a huge gap between the farming conditions of previous generations and those of the present-day generation. Thus, the distinction between indigenous and local knowledge had to be made, with local knowledge, including recently acquired knowledge, made available to farmers mostly through agricultural advisors from the governmental side or from non-governmental organisations. The most frequent methods listed by the farmers included cultural and preventive methods and the use of pesticides of biological or mineral origin. The knowledge transfer to farmers is highly restricted due to various socio-economic factors such as a lack of financial support of extension from the side of the government and a lack of collaboration and linkage between different organisations.

Secondly, it became clear that there is a rather wide gap between the knowledge available in research and the knowledge of today's farmers. As a consequence, a large share of the knowledge existing in rural communities is not documented or evaluated and thus at the risk of becoming extinct, while at the same time, knowledge which is available to advisors and academics does not reach the practitioners, who would need it the most. The latter problem does not only lead to a lack of available methods for the farmers in general, but also to a lack of expertise and technical knowledge in how to apply these methods, which causes their inability to choose and combine different methods wisely and effectively and without harming the health of people or their farming systems.

Lastly, it was found that the farmers were largely very interested in sustainable farming methods, but still frequently resorted to chemical pesticides due to a lack of knowledge about alternatives, the pressure for high yields as a consequence of land fragmentation and newly introduced pests and diseases. Furthermore, exotic breeds of animals are kept in spite of their lacking adaptation to the local environment, thus again requiring expensive chemical inputs from outside. A better knowledge transfer to the farmers would help them to reduce their dependency on external inputs and thus become more self-sufficient and create healthier and more sustainable farming systems.

Steps in the near future could be that farmers are made more aware of the value of their knowledge and motivated to share it, document it and pass it on to the next generation. This could be organised and supported by village council leaders and farmer group chairpersons. Visits to other farms of the same or neighbouring regions could be organised to stimulate exchange, and fields for experiments could be set up to try different or newly acquired methods. NGOs could establish departments or employ staff members for the purpose of exchange with other organisations and governmental advisors. Universities should make efforts to record and document the traditional knowledge which still exists, and to increase their exchange with farmers so that both sides can learn from each other.

As it has been mentioned in the foreword, one of the most important demands from agroecologists is their ability of systemic thinking; and it may be added that in the field of agroecology, the focus is put on the people involved in agriculture. This research has proven the statement made in the above quote in many ways. Agriculture is a field that employs people with very different backgrounds, perspectives and aims. However, only when these people find a way for exchange beyond institutional and social boundaries and the limits of their own perspective, can the system be improved as a whole.

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